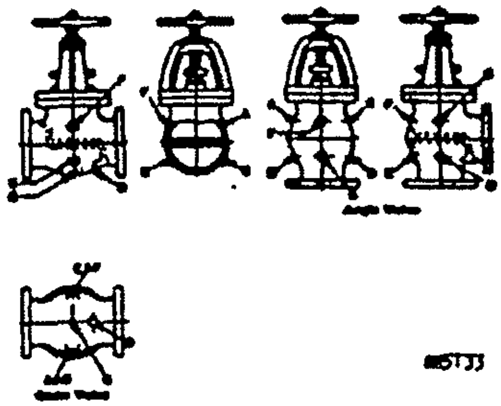


FIGURE 1. Designating of boss locations for drains and by-passes.

3.3.4.3 Root connections. Drain and by-pass line root connections shall be welded to the valve body in accordance with MIL-STD-278. Materials for these lines shall be as follows:

(a) Composition A - ASTM A335, grade P22.
(b) Composition B - ASTM A335, grade P11.
(c) Composition D - ASTM A106, grade B.

3.3.4.4 Bosses. When specified (see 6.2.1), bosses shall be required for valves of class 600 and above in sizes 2-1/2 inches and larger and valves less than class 600 in sizes 4 inches and larger, when these valves are furnished without a by-pass and drain. When specified (see 6.2.1), the valve bodies shall be provided with bosses as shown on "A", "B", and "C" of figure 1 for globe and Y pattern valves and as shown on "E" and "F" of figure 1 for angle valves.

3.3.4.5 Drain and by-pass valves. Drain and by-pass valves shall be in accordance with MIL-V-22094 and shall have welding ends.

3.3.5 Body pattern. The body pattern, globe, angle, or Y pattern shall be as specified (see 6.2.1).

3.3.6 Port arrangement. Unless otherwise specified (see 6.2.1), the port arrangement on globe valves shall be in-line.

3.3.7 Weights and center of gravity. The manufacturer shall supply a calculated weight with his proposal. After completion of the first valve, a weight shall be shown on the drawing. When specified (see 6.2.1), the manufacturer shall submit center of gravity information for valves weighing in excess of 200 pounds. The estimated center of gravity location and the calculated center of gravity shall be as shown on the drawings. Handwheel operated, welded end globe, angle, and Y pattern valves shall not exceed the maximum weights listed in table III. Weights are based on valves with welded ends and do not include weights of drains, by-passes, operators, etc. Weights of valves in classes and sizes not listed in table III are not required.

TABLE III. Maximum weights of welded end valves.

Valve size (inches)	Valve weights						
	Class 150	Class 300	Class 400	Class 600	Class 900	Class 1500	Class 2500
2-1/2	64	88	--	100	--	165	450
3	64	105	--	155	223	220	670
4	108	180	240	230	414	530	800
5	136	250	355	485	515	800	1775
6	207	385	730	600	778	880	2290
8	307	650	1100	800	840	1500	3500
10	500	1020	1630	1620	1800	2500	5000
12	730	1610	2090	2250	2500	3000	--
14	--	2375	--	3510	3900	3950	--
16	--	3000	--	--	5000	5600	--

3.3.8 Face-to-face and end-to-end dimensions. Face-to-face and end-to-end dimensions shall be in accordance with ANSI B16.10.

3.3.9 Shock and vibration. Valves shall withstand the shock requirements conforming to grade A, class I, type C of MIL-S-901 and MIL-STD-798. When specified (see 6.2.1), valves shall meet the vibration requirements of MIL-STD-167-1, type I.

3.3.9.1 Acceptance criteria for shock shall be as follows:

(a) Momentary malfunction at the time of the impact blow is permitted and acceptable.
(b) Permanent deformation, misalinement, and functional impairments shall be cause for rejection.
(c) Permissible seat leakage shall be as specified in 4.6.5.2.

3.3.9.2 Shock and vibration with power operators. When power operators (other than handwheels) are required, shock and vibration shall be conducted on the assembly of the valve operator as a unit.

3.3.10 Bonnet and yoke construction.

3.3.10.1 Pressure seal and breech lock bonnets. Valves classes 600, 900, 1500, and 2500 shall have pressure seal or breech lock bonnets.

3.3.10.1.1 Threads. When retaining rings are threaded, the threads shall be either chromium or nickel-plated.

3.3.10.1.2 Bonnet seal rings. Bonnet seal rings shall provide a seal either by plastic or elastic expansion. Where a seal is obtained by means of plastic expansion, the seal ring shall have a Brinell hardness number (BHN) of 100 maximum. Where a seal is obtained by means of elastic expansion, the seal ring shall have a BHN of 140 maximum. Seal rings shall be silver-plated. Each manufacturer shall supply a list detailing oversized seal rings for repair purposes. The bonnet seal ring region of the valve body shall be inlayed with corrosion-resisting steel.

3.3.10.2 Flanged bonnets. Valves of classes 150, 300, and 400 shall have bonnets with the joint faces of bonnet flanges of the male and female or small tongue and groove type and spiral wound gaskets.

3.3.10.2.1 Bearing surfaces. Bearing surfaces of nuts and bolt heads and their respective mating surfaces on the valves shall be machine finished.

3.3.10.2.2 Fasteners. Fasteners shall be as follows:

(a) Through-bolt type shall be bolt studs with ends threaded the entire length.
(b) Studs of the single nut type shall have 1-1/4 diameters fully formed thread engagement, lead and vanishing threads shall not be considered.
(c) Cap screws shall have 1 diameter fully formed thread engagement, lead and vanishing threads shall not be considered.

3.3.10.3 Yoke construction. Valves shall be of the outside screw and yoke design.

3.3.11 Stuffing boxes and glands.

3.3.11.1 Stuffing boxes. Stuffing boxes shall be of a depth to accommodate packing that will assure a pressure tight seal at the rated pressure and temperature of the valve and to assure a positive engagement between the stuffing box and gland.

3.3.11.2 Glands. Stuffing box glands shall be secured and adjusted by a bolting arrangement which by adjustment will insure tightness of the stuffing box under all operating conditions. Bearing surface between the gland follower and the gland flange shall be spherically finished.

3.3.12 Trim.

3.3.12.1 Stem. Valve stems shall have modified Acme type threads.

3.3.12.1.1 The stem of a stop check valve shall not be attached to the disc. The end of the stem shall be constructed to serve as a disc guide throughout the full travel of the disc.

3.3.12.2 Disc construction.

3.3.12.2.1 Attachment of the disc to the stem of stop valve shall be of swivel construction. The use of balls or of slip-on type is prohibited in the design of the swivel feature in the stem to disc attachment. Furthermore, the combined design features of the disc and the swivel attachment shall be such that the disc will not spin when subject to the normal flow conditions of the valve.

3.3.12.2.2 The disc of stop check valves shall be of the piston guide and dash pot design. The disc shall fit into the body in such a manner as to serve as a guide during the full travel of the disc. The dash pot effect shall provide an effective cushion for the disc and prevent vibration and hammer at low velocities or pulsating loads. The disc shall be free of protrusions that could cause spinning of the disc.

3.3.12.2.3 For stop valves, provision shall be made to prevent galling between the end of the stem and the disc. This may be accomplished by the insertion of a hardened washer (485 Brinell minimum) between the stem and disc, or by a pad of stellite inlaid on the inside of the disc at the point of contact or on the bottom of the stem. A cast stellite disc shall be satisfactory to meet this requirement.

3.3.12.3 Main seat construction. Seats may be of any of the following constructions:

(a) Integral.
(b) Threaded.
(c) Welded-in.

When the threaded construction is used in valves intended for steam service, the seat ring shall be seal welded circumferentially so as to prevent leakage past the seat rings.

3.3.12.4 Back seat. Valves shall have a positive back seat. Class 600 and higher shall have hard facing (HF) back seats (see 3.3.12.6).

3.3.12.5 Valve trim material. Unless otherwise specified (see 6.2.1), valve trim materials shall be in accordance with table IV.

TABLE IV. Valve trim materials.

Service	Valve trim symbols 1/			
	Stem	Disc 2/	Seat 2/	Temperature limitation °F
Steam 3/	Cr 13	HF 5/	HF	1050
Water 4/	Cr 13	Ni-Cu	Cr 13	750
	Cr 13	HF	HF	1050
Oil	Cr 13	Ni-Cu	Cr 13	500
	Cr 13	Cr 13	Cr 13	1000
	Cr 13	HF	HF	1050

See footnotes at top of next page.

1/ HF may be substituted for other seats and discs under all steam temperature and service conditions.

2/ Where unlike seats and discs are used, either the seat or the disc may be Cr 13 or Ni-Cu at the manufacturer's option.

3/ Steam valves shall have HF seats and discs.

4/ Water valves pressure class 600 and higher shall have HF seats and discs.

3.3.12.6 Hard facing. Welding materials shall be in accordance with type MIL-RCoCr-A of MIL-R-17131. The minimum finished thickness of HF seating surfaces shall be 1/32 inch.

3.3.13 Valve handwheels.

3.3.13.1 Rotation. Valves shall close by clockwise rotation of the handwheel when facing the handwheel.

3.3.13.2 Material and design. Handwheels smaller than 11 inches in diameter shall be of commercial design and manufactured from steel, ductile iron, malleable iron, or aluminum. Handwheels 10 inches in diameter and larger shall be of aluminum alloy or cast steel in accordance with the general dimensions of Drawing 5000-S4824-1385620. Stem handwheel connection shall be in accordance with Drawing 5800-S4824-1385620.

3.3.13.3 Size. Handwheels shall be sized so that a tangential force of not more than the value specified in table V is required to be exerted on the rim of the handwheel to effect tight closure (see 4.6.5.2). Valve operating devices may be necessary to accomplish effective closure.

TABLE V. Maximum allowable tangential force to seat valves based on valve handwheel size.

Handwheel diameter	Tangential force
(Inches)	(Pounds)
2	90
3	98
4	106
5	112
6	118
7	121
8	124
9	127
10	130
11	133
12	135
14	138
16	141
18	144
21	147
24	150
27	150
30	150
36	150

3.3.13.4 Hammer-blow wheel. Valves of class 600, sizes 4 inch and larger, and valves of class 1500, sizes 3 inch and larger shall be equipped with hammer-blow wheels unless a valve operator is specified.

3.3.13.5 Toggle operators. Toggle operators shall be of the double toggle design and shall consist of 8 equal length toggle arms with the toggle arrangement being mounted on the valve yoke. Valve clamp ring shall not be a part of the valve yoke or toggle operator. Toggle design shall include a means of avoiding overstressing of the valve stem by providing ample stops to limit the stress applied to the valve stem. A means shall be provided to assure a constant seating load on the valve seats when the valve is in the closed position.

3.3.13.6 Power operators. Valves shall be designed to assure means of mounting c... ...rcial type power operators on the valve.

3.3.14 Seat leakage. Unless otherwise specified (see 6.2.1), allowable seat leakage is considered to be leakage of water not in excess of 10 cubic centimeters (cm^3) per hour per inch of nominal pipe size when tested in accordance with 4.6.5.2.

3.3.15 Lubrication. Yoke bushings 2-1/2 inches and larger shall be equipped with a 1/8-inch threaded or push designed, type III lubricating fitting in accordance with MIL-F-3541 and MS15003.

3.3.16 Welding and fabrication.

3.3.16.1 Welding. Welding shall be in accordance with MIL-STD-278.

3.3.16.2 Fabrication. Fabricated assemblies shall be stress relieved as units prior to finish machining. Stress relieving shall be done in accordance with MIL-STD-278.

3.3.17 Assembly and disassembly. Valve design and construction shall assure that assembly and disassembly of the valve can be accomplished onboard ship by Navy shipboard personnel without the need for special training or special tools. Special tools are defined as those tools not listed in the National Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Service (DCAS). Design and external configuration shall be such as to permit the use of a portable boring machine to repair the bonnet inlay of the valve with the valve in place in the piping system.

3.4 Body markings and identification plates.

3.4.1 Body markings. Valve bodies shall have the class and manufacturer's name or trademark cast or forged integral with the valve body. Globe valves shall have a bridge wall marking in addition to the above markings. When necessary, metal stamping shall be permitted on the neck of the valve body or other similar areas not subjected to high stress in service.

3.4.2 Identification plates. Identification plates made of corrosion-resisting steel ...ass shall be permanently fastened to a part of the valve not subjected to working ...sure, preferably the yoke. Drawings of the proposed identification plates shall be reviewed by the procuring activity prior to their manufacture, and shall include the following data or a space therefor:

(a) Manufacturer's name or trademark.
(b) Size of valve and class.
(c) Stop check valve, if so constructed.
(d) Body and bonnet material composition.
(e) Valve trim identification (stem-disc-seat).
(f) Manufacturer's identification number (optional).
(g) Manufacturer's drawing number.
(h) MIL-V-22052.
(i) Component identification number (CID).
(j) National stock number (NSN).

3.5 Onboard repair parts. Onboard repair parts shall be as specified in table VI.

TABLE VI. Onboard repair parts.

Item	Quantities
Packings, gaskets, bonnet seal rings	30 percent of ship order but not less than two sets for each size, composition, and class
Valve disc and stem assembly	5 per...nt of ship order but not less than one complete set for each size, composition, and class

3.5.1 Repair parts (and special tools if required). When specified (see 6.2.1), re...ir parts (and special tools if required) shall be furnished in accordance with M...-STD-1552 and MIL-STD-1561.

3.6 Technical data. The contractor shall prepare technical data in accordance with the data ordering document included in the contract or order (see 6.2.2), and as specified in 3.6.1 through 3.6.2.

3.6.1 Drawings. In addition to the drawing content required by the data ordering document (see 6.2.2), the following features shall be included:

(a) Accurately scaled sectional assembly which clearly depicts the design and construction of the valve.
(b) Bill of material listing specification, grade, condition, and any other data required to fully identify the properties of the materials proposed.
(c) Details of the seat, disc, and stem assembly and all other replaceable internal trim.
(d) Layout of the pressure-containing envelope (body and bonnet) giving dimensions which control compression of the spiral-wound gaskets and pressure seal ring. This is to assure that where remachining is necessary to repair the gasket-sealing surfaces on these parts, that compensating cuts can be accurately made to restore original gasket compression. This layout shall also specify the dimensional limits of such corrective remachining within which function of the valve remains unaffected.
(e) Recommended assembly torques, or equivalent procedures, for making up all joints and threaded assemblies.
(f) Tabulation of required gasket characteristics including all dimensions (with tolerances) and load versus compression characteristics (with tolerances).
(g) Mark areas to be radiographic, magnetic particle, or dye penetrant inspected.
(h) Dimensions-overall, accessibility space including disassembly clearances and all dimensions pertinent to installation.
(i) Surface finishes-show finish marks for all hard face surfaces and bearing areas.
(j) Name of laboratory conducting tests and date of previous successful shock and vibration tests.
(k) Welding procedure for seal canopy. Welding procedures shall include the following:

(1) Detail of weld.
(2) Welding process.
(3) Welding current (where applicable).
(4) Filler metal.
(5) Preparation.
(6) Interpass temperature.
(7) Technique.
(8) Post heat treatment.
(9) Provide a table listing size of weld, number of passes, electrode diameter, and welding characteristics.

3.6.1.1 Certification data. Certification data sheets shall be prepared by the contractor (see 6.2.2). In addition to the general requirements, the certification data sheets shall include the following:

(a) Class.
(b) Pressure and temperature rating.
(c) Body and bonnet material.
(d) Seat, disc, and stem material.
(e) Type of power operator, if required.
(1) Shock and vibration tests of valve with the power operator attached.

3.6.2 Manuals. In addition to the general requirements for technical manuals (see 6.2.2), the following shall be included as part of the contents:

(a) Drawings for the valve (including certification data sheet). Drawings shall be supplemented by additional illustrations where necessary to adequately illustrate operation and maintenance. These additional illustrations may consist of blowouts, partial or full sections, etc., and may eliminate extraneous lines and details to clarify the interaction of parts.
(b) Table listing wrench sizes and assembly torques (or other equivalent procedures) for making up all joints and threaded assemblies.
(c) Instructions to permit overhaul by shipyard or other repair facility. These should include procedures for checking all critical dimensions subject to wear or change and the acceptable dimensional limits, surface finish condition, etc. Also, the appropriate procedure (that is, part replacement, correction at repair facility, or repair at manufacturer's facility) which should be followed to correct each case of damage or wear.

(d) Detailed disassembly and reassembly procedures. In addition to providing procedures for the complete disassembly and reassembly of the equipment, maintenance and troubleshooting sections shall contain, or refer to, only the limited disassembly and reassembly required to accomplish each particular operation. This is intended to reduce the possibility of unnecessary disassembly and unnecessary disturbance of adjustments when performing specific or limited maintenance or troubleshooting operations.
(e) Adjustment procedures.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Inspection system program plan. The contractor shall provide and maintain an inspection system program plan in accordance with the data ordering document included in the contract or order (see 6.2.2).

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) Qualification inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 Qualification inspection. Qualification inspection shall be conducted at a laboratory satisfactory to the Naval Ship Engineering Center (NAVSEC). Qualification shall consist of the examinations and tests specified in 4.5 through 4.7.

4.3.1 Qualification inspection samples. Sample valves submitted for qualification inspection shall be of the 2-1/2 inch size, special class 1500, composition B. Valves of the 2-1/2-inch size, class 1500, composition B, which have passed the qualification tests will qualify valves in sizes 2-1/2 inches and larger of all compositions, classes 600, 900, 1500, and 2500, provided variations in design throughout the various sizes and classes are demonstrated by analysis to be satisfactory to NAVSEC.

4.3.2 Authorization for qualification tests. Prior to authorization of qualification tests, the drawings specified in 3.6.1 shall be submitted to NAVSEC for review.

4.4 Quality conformance inspection. Each special class valve shall be examined and tested as specified in 4.5, 4.6.1, and 4.6.5. Each standard class valve shall be examined and tested as specified in 4.5, 4.6.1.4, and 4.6.5. The DCAS shall normally accept certification that materials comply with the specification, however, proof of compliance may be required by the DCAS.

4.5 Visual and dimensional examination. Valves shall be visually and dimensionally examined to verify compliance with the requirements of this specification not involving tests.

4.6 Tests.

4.6.1 Nondestructive testing.

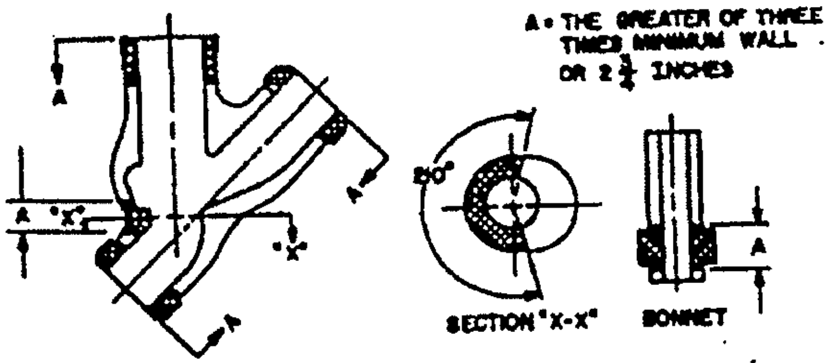
4.6.1.1 Pressure containing castings of valves shall be 100 percent radiographically inspected when the service pressure or temperature will exceed the values listed in table VII. Inspection shall be in accordance with the following:

(a) Radiographic inspection shall conform to MIL-STD-271.
(b) Radiographic acceptance shall conform to MIL-STD-278.
(c) Radiographic coverage shall conform to the shaded areas shown on figures 2 and 3.

TABLE VII. Pressure or temperature criteria for nondestructive testing.

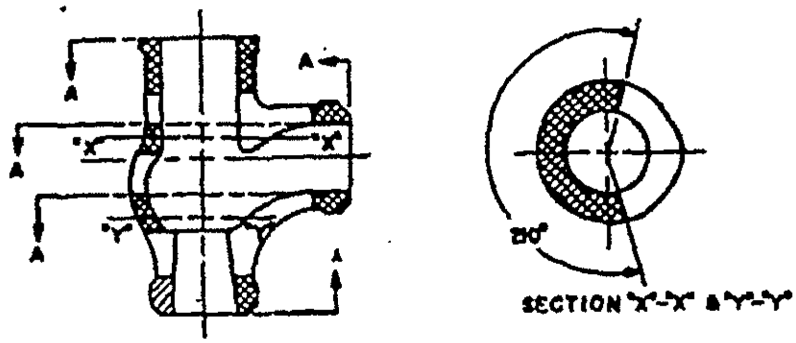
Service1/	Gage pressure pounds per square inch (lb/in^2)	Temperature (°F)
Steam	225	500
Water	600	200
Oil	300	150

1/ When valves are used in services other than those listed, the criteria for nondestructive testing shall be as specified (see 6.2.1).



SH 11186

FIGURE 3. "Y" pattern globe body (pressure seal bonnet).



SH 11260

FIGURE 3. Angle body (pressure seal bonnet) bonnet same as "Y" pattern globe.

4.6.1.2 Pressure containing forgings of valves shall be 100 percent magnetic particle inspected in accordance with MIL-STD-271 when the service pressure or temperature exceeds the values listed in table VII. Forgings shall be free from flaws such as seams, cracks, laps, porosity, scale, flakes, and all other defects detrimentally affecting the suitability of the forging for the service intended.

4.6.1.3 Defects to be repaired. The following shall apply to those parts inspected in accordance with 4.6.1.1 and 4.6.1.2:

(a) Defects less than 0.030 inch in depth need not be repaired provided the bottom of the defect is rounded and visible and the minimum wall thickness is maintained.
(b) Defects greater than 0.030 inch in depth but less than 15 percent of the wall thickness shall be repaired by removing the defective material. This material shall be removed by drilling or grinding to a bottom radius of at least three times the depth of the defect. The depth of the finished repair shall be less than 15 percent of the undamaged wall thickness. Sharp corners shall be faired into the base metal. Welding is not required to effect a repair of this nature, provided the minimum wall thickness is maintained.
(c) Defects greater than 15 percent of the wall thickness shall be repaired by removing the defective material and welding. The material shall be removed by grinding or drilling and then welded in accordance with 3.3.16. The crown of the weld shall be blended into the base metal.

4.6.1.4 Hard faced seating. Hard faced seating surfaces shall be liquid penetrant inspected in accordance with MIL-STD-271 after rough machining and shall be free of cracks or crack-like/defects.

4.6.2 Cold tests. Cold tests shall be performed as follows:

(a) Operation - 10 cycles.
(b) Hydrostatic - shell and closure tests (see 4.6.5.1 and 4.6.5.2).

4.6.3 Hot tests. Hot tests shall be conducted with a gage pressure of 1200 lb/in^2 steam at 950°F and shall be performed in the following sequence:

(a) Thermal shock.
(b) Operation - 200 cycles.

4.6.3.1 Thermal shock tests. Valves shall be thermal shocked ten times by reducing the steam temperature from 950°F to 600°F in not more than 30 seconds.

4.6.3.2 Operational tests. Steam shall be passed through the valve for a period of not less than 48 hours. During this period two securing trials shall be made to determine if the valve remains tight while and after cooling to ambient temperature, and two warm-up trials shall be made to determine the torque required to open the valve which has been closed while cold. The valve shall be cycled a minimum of 200 times and the operating torque shall be recorded periodically during the cycling.

4.6.4 Shock and vibration. Valves shall be shock and vibration tested to determine conformance to the requirements specified in 3.3.9.

4.6.5 Hydrostatic tests. Valves shall be subjected to the tests specified in 4.6.5.1 for strength and porosity and the tests specified in 4.6.5.2 for tightness. Water temperature shall not exceed 100°F.

4.6.5.1 Shell test. Valves shall be given a shell test at a gage pressure no less than 1-1/2 times the 100°F rating, rounded off to the next higher 25 lb/in^2 increment. The test shall be made with water, which may contain a corrosion inhibitor, or with kerosene, or with other suitable fluid, provided such fluid has viscosity not greater than that of water, at a temperature not above 125°F. Visually detectable leakage through pressure boundary walls is not acceptable. Test duration shall be not less than as follows:

Valve size ips (inches)	Test time (seconds)
3-1/2 - 8	60
10 and larger	180

Test shall be made with the valve in the partially open position. Leakage through the stem packing shall not be cause for rejection.

4.6.5.2 Closure tests. Following the shell test, valves shall be given a closure test. Each valve 10 ips and larger, regardless of class and each valve in the size range ips 4 through ips 8, class 600 and higher shall be given a closure test using a fluid described in 4.6.5.1 at a pressure no less than 110 percent of the 100°F pressure rating. Each valve ips 4 through ips 8, class less than 600 and each valve in size less than ips 4, regardless of the pressure rating shall, be given either a fluid closure test at a pressure no less than 110 percent of the 100°F pressure rating or a gas closure test at a minimum gage pressure of 80 lb/in^2. The test pressure shall be applied successively on each side of the closed valve. Leakage rate of fluid test shall not exceed 10 cm^3, per hour per inch of nominal pipe size. Air test under water shall not allow the formation of a free air bubble. Duration of closure test shall be the same as specified in 4.6.5.1.

4.6.5.2.1 For globe and angle valves, the test pressure shall be applied across the closure member in the direction producing the most adverse seating condition. A stop check valve or other valve type designed to be a one-way valve, requires a closure test only in the appropriate direction.

4.6.5.2.2 Valves designed for operating conditions, that have the pressure differential across the closure member limited to values less than the 100 percent pressure rating and having closure members or actuating devices (direct, mechanical, fluid, or electrical) that would be subject to damage at high differential pressures, shall be tested as described above except that the closure test may be reduced to 110 percent of the maximum specified closed position differential pressure. This exception may be exercised upon agreement between the Navy and manufacturer. The manufacturer's nameplate data shall include reference to any such limitations.

4.7 Examination after qualification tests. Valves shall be disassembled and shall be visually and dimensionally examined for damage and wear. Disassembly and reassembly shall be performed to determine the practicability of maintaining a valve of this design for shipboard use (see 3.3.17). The maintainability demonstration shall be conducted by removing and replacing the pressure seal ring, disc, and stem. This shall be accomplished by following the instructions in the technical manual. Particular emphasis shall be directed towards the possibility of loss of small parts by the maintenance crew.

4.8 Inspection of preparation for delivery. Preservation-packaging, packing, and marking shall be inspected for compliance with section 5 of this document.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.4.)

5.1 Preservation-packaging, packing, and marking. Valves shall be individually preserved-packaged level A or C, packed level A, B, or C, as specified (see 6.2.1), and marked in accordance with MIL-V-3.

5.2 Repair parts and tools. Repair parts and tools shall be preserved-packaged, packed, and marked for the level specified (see 6.2.1) in accordance with MIL-R-196.

5.3 Cushioning, dunnage, and wrapping materials.

5.3.1 Level A preservation-packaging and levels A and B packing. Use of all types of loose-fill materials for packaging and packing applications such as cushioning, filler, or dunnage is prohibited for materials destined for shipboard installation/stowage.

5.3.2 Level C preservation-packaging and packing. When loose-fill type materials are used for packaging and packing applications such as cushioning, filler, and dunnage, all containers (unit, intermediate, and shipping) shall be marked or labelled with the following information:

"CAUTION

Contents cushioned etc., with loose-fill material.
Not to be taken onboard ship.
Remove and discard loose-fill material before shipboard stowage.
If required, recushion with cellulosic material, bound fiber, fiberboard, or transparent flexible cellular material."

5.3.3 Cushioning, filler, dunnage, and wrapping materials selected, whenever available, shall exhibit improved performance for resistance to fire.

6. NOTES

6.1 Intended use. Globe, angle, and Y pattern valves are intended for use in steam, water, and oil service.

6.2 Ordering data.

6.2.1 Procurement requirements. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Composition and rating required (see 1.2).
(c) End preparation (see 3.3.3).
(d) Size required (see tables II and III).
(e) Nonstandard sizes of drains and by-passes (see 3.3.4.1).
(f) Service conditions.
(g) Quantity required.
(h) Location of drains and by-passes (see 3.3.4.2).
(i) Boss requirements (see 3.3.4.4).
(j) Pattern required (see 3.3.5).
(k) Port arrangement on globe valves (see 3.3.6).
(l) Center of gravity location (see 3.3.7).

(m) Whether vibration test is required (see 3.3.9).
(n) Valve trim (see 3.3.12.5).
(o) Allowable seat leakage (see 3.3.14).
(p) Repair parts and special tools required (see 3.5.1).
(q) Criteria for nondestructive testing when valves are used in services other than as listed (see table VII).
(r) Level of preservation-packaging and packing required (see 5.1).
(s) Level of preservation-packaging and packing of repair parts and tools required (see 5.2).

6.2.2 Data requirements. When this specification is used in a procurement which invokes the provision of the "Requirements for Data" of the Armed Services Procurement Regulations (ASPR), the data identified below, which are required to be developed by the contractor, as specified on an approved Data Item Description (DD Form 1664), and which are required to be delivered to the Government, should be selected and specified on the approved Contract Data Requirement List (DD Form 1423) and incorporated in the contract. When the provisions of the "Requirements for Data" of the ASPR are not invoked in a procurement, the data required to be developed by the contractor and required to be delivered to the Government should be selected from the list below and specified in the contract.

Paragraph	Data requirements	Applicable DID	Option
3.6.1 and 3.6.1.1	Drawings, engineering and associated lists	DI-E-7031	Level 2 Design activity designation - Contractor Drawing Number - Contractor Delivery of hard copies - Procuring activity
3.6.2	Manuals	DI-M-2043	MIL-M-15071, type I
4.1.1	Inspection system program plan	DI-R-4803	---

(Copies of data items descriptions required by the contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the procuring/purchasing activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item procured to this specification. This does not apply to specific data which may be required for each procurement, regardless of whether an identical item has been supplied previously (for example, test reports).

6.2.2.2 Where the Government has limited rights in the data shown on the drawings, as determined by the contractual provisions regarding rights in technical data, the drawings may be marked with a legend. If used, the "Limited Rights Legend" of ASPR should be used.

6.3 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable Qualified Products List QPL-22052 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Ship Engineering Center, Department of the Navy, Washington, DC 20362, and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.4 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in section 2 do not apply when material and parts are procured by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 6, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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DOD STANDARDIZATION PROGRAM AND DOCUMENTS DIVISION
DEPARTMENT OF THE NAVY
WASHINGTON, DC 20362

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)* ☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*:
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

Exhibit B

MIL-V-22052D(SH)
20 March 1978
SUPERSEDING
MIL-V-22052C(SHIPS)
11 April 1961
(See 6.5)

MILITARY SPECIFICATION

VALVES, STOP AND STOP CHECK, GLOBE, ANGLE, AND Y PATTERN, CAST OR

FORGED CARBON OR ALLOY STEEL, OUTSIDE SCREW AND YOKE

(SIZES 2-1/2 INCHES AND LARGER)

This specification is approved for use by the Naval Sea Systems Command and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers steel globe, angle, and Y pattern valves in sizes 2-1/2 inches and larger.

1.2 Classification. Valves shall be classified in accordance with the composition and rating (see 1.2.1 and 1.2.2), as specified (see 6.2.1).

1.2.1 Composition. Valves shall be of the following compositions:

Composition A:
Chromium - 2-1/4 percent.
Molybdenum - 1 percent.
Composition B:
Chromium - 1-1/4 percent.
Molybdenum - 1/2 percent.
Composition C:
Carbon steel.

1.2.2 Rating. Valves shall be rated as standard (150, 300, or 400 class), and as special (600, 900, 1500, or 2500 class) in accordance with ANSI B16.34.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL
HH-P-46 - Packing; Asbestos, Sheet, Compressed.

MILITARY
MIL-V-3 - Valves, Fittings, and Flanges (Except for Systems Indicated Herein); Packaging of.
MIL-R-196 - Repair Parts for Internal Combustion Engines, Packaging of.
MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-F-3541 - Fittings, Lubrication.
MIL-A-7021 - Asbestos Sheet, Compressed, for Fuel, Lubricant, Coolant, Water, and High Temperature Resistant Gaskets.
MIL-R-17131 - Rods and Powders, Welding, Surfacing.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Ship Engineering Center, SEC 6124, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MILITARY (Continued)
MIL-P-17303 - Packing Materials, Plastic Metallic and Plastic Nonmetallic.
MIL-G-21032 - Gaskets, Metallic-Asbestos, Spiral Wound.
MIL-V-22094 - Valves, Globe, Y-Pattern Globe, Stop Check, Angle, Flanged Bonnet, Manually Operated Nominal Pipe Size (NPS), 2 Inches and Less.
MIL-P-24377 - Packing Material, Asbestos, Braided, Impregnated With TFE (Polytetrafluoroethylene), Surface Lubricated.

STANDARDS

MILITARY
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-271 - Nondestructive Testing Requirements for Metals.
MIL-STD-278 - Fabrication Welding and Inspection; and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels in Ships of the United States Navy.
MIL-STD-798 - Nondestructive Testing, Welding, Quality Control, Material Control and Identification and HI-Shock Test Requirements for Piping System Components for Naval Shipboard Use.
MIL-STD-1552 - Provisioning Technical Documentation, Uniform DOD Requirements for.
MIL-STD-1561 - Provisioning Procedures, Uniform DOD.
MS15003 - Fittings, Lubrication (Hydraulic); Surface Check, 1/8 Pipe Threads.

DRAWINGS

MILITARY
NAVSHIPS 5000-S4824-1385620 - Handwheels for Valves.
NAVSEA 803-5001021 - Pressure Seal Ring-Standard and Oversize-Valve Pressure Class 600-1500.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
B16.10 - Face-to-Face and End-to-End Dimensions of Ferrous Valves.
B16.34 - Steel Butt-Welding End Valves.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, New York 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
A105 - Forgings, Carbon Steel, for Piping Components.
A106 - Seamless Carbon Steel Pipe for High-Temperature Service.
A182 - Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
A193 - Alloy-Steel and Stainless Steel, Bolting Materials for High-Temperature Service.
A194 - Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
A216 - Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service.
A217 - Martensitic Stainless Steel and Alloy Steel Castings for Pressure-Containing Parts Suitable for High-Temperature Service.
A335 - Seamless Ferritic Alloy Steel Pipe for High-Temperature Service.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Qualification. Valves with a 600, 900, 1500, or 2500 special class rating, furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.3 and 6.3).

3.2 Materials. Materials shall be as specified in table I. Materials for parts other than those listed in table I shall be selected so as to prevent galling, seizing, or excessive wear of operating parts. Cast iron and aluminum shall be used only for those parts where permitted in this specification. Magnesium alloys shall not be used. Clearances shall be adequate to prevent interferences due to thermal expansion.

TABLE I. List of materials.

Name of parts	Materials form	Composition A	Composition B	Composition D
		Applicable documents		
Body, bonnet	Forgings or castings	ASTM A182, grade F22 ASTM A217, grade WC9	ASTM A182, grade F11 ASTM A217, grade WC6	ASTM A105, ASTM A216, grade WCB[1/]
Retaining ring and yoke	Forgings or castings	ASTM A182, grades F22 or F11 ASTM A105 ASTM A217, grades WC9 or WC6 ASTM A216, grade WCB		
Studs for bonnets	Alloy steel for high temperature bolting	ASTM A193, grade B16	ASTM A193, grade B16	ASTM A193, grades B7 and B16
Nuts for bonnets	Heavy semi-finished hexagon carbon and alloy steel for high temperature bolting	ASTM A194, grade 4	ASTM A194, grade 4	ASTM A194, grades 2H and 4
Standard pressure seal rings and standard oversized pressure seal rings[2/]	Soft carbon steel, silver-plated	Commercial		
Gaskets (for flanged bonnets)	Spiral wound	MIL-G-21032, type I, class A or B		
	Compressed asbestos sheet	MIL-A-7021 (where fuel resistance is necessary) HH-P-46, class 1 (except where fuel resistance is necessary)		
Packing	Asbestos impregnated with polytetrafluoroethylene	MIL-P-24377 (nonlubricated) service temperature not to exceed that of saturated steam MIL-P-24377, superheated steam total temperature in excess of 350°F		
	Plastic, metallic or nonmetallic	MIL-P-17303, symbol 1111 for temperatures above 500°F		
Nuts, bolts, washers, bushings, liners	Materials used in the construction of these parts other than specified above shall be in accordance with the material specifications shown on the manufacturer's drawings (see 3.4.1)			
Valve trim	(See table IV)			

1/ Bonnet material for composition D valves may also be grade WC6 of ASTM A217.

2/ Oversized seal rings may be used in the repair of pressure seal bonnets, (i.e.) as shown on Drawing 803-5001021.

3.3 Design. Unless otherwise specified herein, valves, valve parts, and design features and parameters shall conform to ANSI B16.34.

3.3.1 Pressure-temperature ratings. The design and pressure-temperature rating shall be in accordance with ANSI B16.34, except the maximum allowable temperature for composition D shall be 775°F. Pressure seal valves shall be designed in such a manner as to permit repair by the use of oversize seal rings. The detail design of the oversize seal ring shall be as shown on Drawing 803-5001021.

3.3.2 End connections. Valve end connections shall withstand the forces and moments imposed by the connecting pipe to which they are attached. For design purposes, the maximum value of the fiber stress in the connecting pipe produced by these forces and moments shall be considered to be equal to 0.2 percent offset yield stress of the piping material at room temperature.

3.3.3 End preparation. Design of welding ends and flange facing shall be as specified (see 6.2.1).

3.3.4 Drains and by-passes. Drains and by-passes shall be in accordance with the requirements specified in 3.3.4.1 through 3.3.4.5. A drain shall consist of a nipple and drain valve. A by-pass shall consist of connecting lines and a by-pass valve.

3.3.4.1 Size of drains and by-passes. Standard drain and by-pass sizes shall be as shown in table II. Nonstandard sizes shall be as specified (see 6.2.1).

TABLE II. Standard drain and by-pass sizes.

Valve size (inches)	Size of by-pass and drains (inches)
2-1/2	1/2
3	1/2
4	3/4
5	3/4
6	3/4
8	3/4
10	1
12	1
14	1-1/4
16	1-1/4

3.3.4.2 Location. The location of drains and by-passes shall be specified by referencing the letter designation of the desired bosses (see figure 1 and 6.2.1). Bosses shall be sufficient distance away from seating area to allow welding of replacement by-pass line without damage to valve seat. When nonstandard locations are required, a drawing shall be furnished by the user indicating the desired location. When a location is not specified, the following standard locations shall be used:

(a) By-pass - "A" to "B" of figure 1 (for globe and Y pattern valves), "E" to "F" of figure 1 (for angle valves).
(b) Drain - "C" of figure 1 (for globe and Y pattern valves).

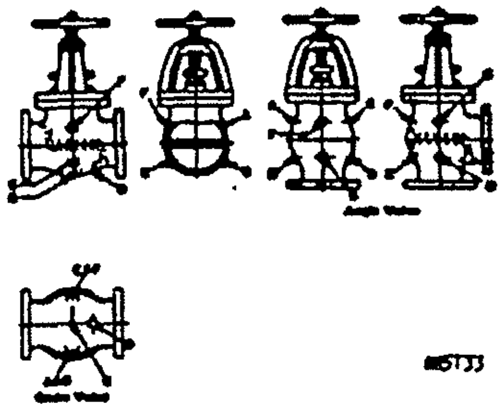


FIGURE 1. Designating of boss locations for drains and by-passes.

3.3.4.3 Root connections. Drain and by-pass line root connections shall be welded to the valve body in accordance with MIL-STD-278. Materials for these lines shall be as follows:

(a) Composition A - ASTM A335, grade P22.
(b) Composition B - ASTM A335, grade P11.
(c) Composition D - ASTM A106, grade B.

3.3.4.4 Bosses. When specified (see 6.2.1), bosses shall be required for valves of class 600 and above in sizes 2-1/2 inches and larger and valves less than class 600 in sizes 4 inches and larger, when these valves are furnished without a by-pass and drain. When specified (see 6.2.1), the valve bodies shall be provided with bosses as shown on "A", "B", and "C" of figure 1 for globe and Y pattern valves and as shown on "E" and "F" of figure 1 for angle valves.

3.3.4.5 Drain and by-pass valves. Drain and by-pass valves shall be in accordance with MIL-V-22094 and shall have welding ends.

3.3.5 Body pattern. The body pattern, globe, angle, or Y pattern shall be as specified (see 6.2.1).

3.3.6 Port arrangement. Unless otherwise specified (see 6.2.1), the port arrangement on globe valves shall be in-line.

3.3.7 Weights and center of gravity. The manufacturer shall supply a calculated weight with his proposal. After completion of the first valve, a weight shall be shown on the drawing. When specified (see 6.2.1), the manufacturer shall submit center of gravity information for valves weighing in excess of 200 pounds. The estimated center of gravity location and the calculated center of gravity shall be as shown on the drawings. Handwheel operated, welded end globe, angle, and Y pattern valves shall not exceed the maximum weights listed in table III. Weights are based on valves with welded ends and do not include weights of drains, by-passes, operators, etc. Weights of valves in classes and sizes not listed in table III are not required.

TABLE III. Maximum weights of welded end valves.

Valve size (inches)	Valve weights						
	Class 150	Class 300	Class 400	Class 600	Class 900	Class 1500	Class 2500
2-1/2	44	88	--	100	--	165	450
3	64	105	--	155	223	220	670
4	108	180	240	230	414	530	800
5	136	250	355	485	515	880	1775
6	207	385	730	600	778	880	2290
8	307	650	1100	800	840	1500	3500
10	500	1020	1630	1620	1800	2500	5000
12	730	1610	2090	2250	2500	3000	--
14	--	2375	--	3510	3900	3850	--
16	--	3000	--	--	5000	5600	--

3.3.8 Face-to-face and end-to-end dimensions. Face-to-face end end-to-end dimensions shall be in accordance with ANSI B16.10.

3.3.9 Shock and vibration. Valves shall withstand the shock requirements conforming to grade A, class I, type C of MIL-S-901 and MIL-STD-798. When specified (see 6.2.1), valves shall meet the vibration requirements of MIL-STD-167-1, type I.

3.3.9.1 Acceptance criteria for shock shall be as follows:

(a) Momentary malfunction at the time of the impact blow is permitted and acceptable.
(b) Permanent deformation, misalignment, and functional impairments shall be cause for rejection.
(c) Permissible seat leakage shall be as specified in 4.6.5.2.

3.3.9.2 Shock and vibration with power operators. When power operators (other than handwheels) are required, shock and vibration shall be conducted on the assembly of the valve operator as a unit.

3.3.10 Bonnet and yoke construction.

3.3.10.1 Pressure seal and breech lock bonnets. Valves classes 600, 900, 1500, and 2500 shall have pressure seal or breech lock bonnets.

3.3.10.1.1 Threads. When retaining rings are threaded, the threads shall be either chromium or nickel-plated.

3.3.10.1.2 Bonnet seal rings. Bonnet seal rings shall provide a seal either by plastic or elastic expansion. Where a seal is obtained by means of plastic expansion, the seal ring shall have a Brinell hardness number (BHN) of 100 maximum. Where a seal is obtained by means of elastic expansion, the seal ring shall have a BHN of 140 maximum. Seal rings shall be silver-plated. Each manufacturer shall supply a list detailing oversized seal rings for repair purposes. The bonnet seal ring region of the valve body shall be inlayed with corrosion-resisting steel.

3.3.10.2 Flanged bonnets. Valves of classes 150, 300, and 400 shall have bonnets with the joint faces of bonnet flanges of the male and female or small tongue and groove type and spiral wound gaskets.

3.3.10.2.1 Bearing surfaces. Bearing surfaces of nuts and bolt heads and their respective mating surfaces on the valves shall be machine finished.

3.3.10.2.2 Fasteners. Fasteners shall be as follows:

(a) Through-bolt type shall be bolt studs with studs threaded the entire length.
(b) Studs of the single nut type shall have 1-1/4 diameters fully formed thread engagement, lead and vanishing threads shall not be considered.
(c) Cap screws shall have 1 diameter fully formed thread engagement. Lead and vanishing threads shall not be considered.

3.3.10.3 Yoke construction. Valves shall be of the outside screw and yoke design.

3.3.11 Stuffing boxes and glands.

3.3.11.1 Stuffing boxes. Stuffing boxes shall be of a depth to accommodate packing that will assure a pressure tight seal at the rated pressure and temperature of the valve and to assure a positive engagement between the stuffing box and gland.

3.3.11.2 Glands. Stuffing box glands shall be secured and adjusted by a bolting arrangement which by adjustment will insure tightness of the stuffing box under all operating conditions. Bearing surface between the gland follower and the gland flange shall be spherically finished.

3.3.12 Trim.

3.3.12.1 Stem. Valve stems shall have modified Acme type threads.

3.3.12.1.1 The stem of a stop check valve shall not be attached to the disc. The end of the stem shall be constructed to serve as a disc guide throughout the full travel of the disc.

3.3.12.2 Disc construction.

3.3.12.2.1 Attachment of the disc to the stem of stop valve shall be of swivel construction. The use of balls or of slip-on type is prohibited in the design of the swivel feature in the stem to disc attachment. Furthermore, the combined design features of the disc and the swivel attachment shall be such that the disc will not spin when subject to the normal flow conditions of the valve.

3.3.12.2.2 The disc of stop check valves shall be of the piston guide and dash pot design. The disc shall fit into the body in such a manner as to serve as a guide during the full travel of the disc. The dash pot effect shall provide an effective cushion for the disc and prevent vibration and hammer at low velocities or pulsating loads. The disc shall be free of protrusions that could cause spinning of the disc.

3.3.12.2.3 For stop valves, provision shall be made to prevent galling between the end of the stem and the disc. This may be accomplished by the insertion of a hardened washer (485 Brinell minimum) between the stem and disc, or by a pad of stellite inlaid on the inside of the disc at the point of contact or on the bottom of the stem. A cast stellite disc shall be satisfactory to meet this requirement.

3.3.12.3 Main seat construction. Seats may be of any of the following constructions:

(a) Integral.
(b) Threaded.
(c) Welded-in.

When the threaded construction is used in valves intended for steam service, the seat ring shall be seal welded circumferentially so as to prevent leakage past the seat rings.

3.3.12.4 Back seat. Valves shall have a positive back seat. Class 600 and higher shall have hard facing (HF) back seats (see 3.3.12.6).

3.3.12.5 Valve trim material. Unless otherwise specified (see 6.2.1), valve trim materials shall be in accordance with table IV.

TABLE IV. Valve trim materials.

Service	Valve trim symbols 1/			
	Stem	Disc 2/	Seat 2/	Temperature limitation °F
Steam 3/	Cr 13	HF 5/	HF	1050
Water 4/	Cr 13	Ni-Cu	Cr 13	750
	Cr 13	HF	HF	1050
Oil	Cr 13	Ni-Cu	Cr 13	500
	Cr 13	Cr 13	Cr 13	1000
	Cr 13	HF	HF	1050

See footnotes at top of next page.

1/ HF may be substituted for other seats and discs under all steam temperature and service conditions.

2/ Where unlike seats and discs are used, either the seat or the disc may be Cr 13 or Ni-Cu at the manufacturer's option.

3/ Steam valves shall have HF seats and discs.

4/ Water valves pressure class 600 and higher shall have HF seats and discs.

3.3.12.6 Hard facing. Welding materials shall be in accordance with type MIL-RCoCr-A of MIL-R-17131. The minimum finished thickness of HF seating surfaces shall be 1/32 inch.

3.3.13 Valve handwheels.

3.3.13.1 Rotation. Valves shall close by clockwise rotation of the handwheel when facing the handwheel.

3.3.13.2 Material and design. Handwheels smaller than 11 inches in diameter shall be of commercial design and manufactured from steel, ductile iron, malleable iron, or aluminum. Handwheels 10 inches in diameter and larger shall be of aluminum alloy or cast steel in accordance with the general dimensions of Drawing 5000-S4824-1385620. Stem handwheel connection shall be in accordance with Drawing 5000-S4824-1385620.

3.3.13.3 Size. Handwheels shall be sized so that a tangential force of not more than the value specified in table V is required to be exerted on the rim of the handwheel to effect tight closure (see 4.6.5.2). Valve operating devices may be necessary to accomplish effective closure.

TABLE V. Maximum allowable tangential force to seat valves based on valve handwheel size.

Handwheel diameter (Inches)	Tangential force (Pounds)
2	80
3	98
4	106
5	112
6	118
7	121
8	124
9	127
10	130
11	133
12	135
14	138
16	141
18	144
21	147
24	150
27	150
30	150
36	150

3.3.13.4 Hammer-blow wheel. Valves of class 600, sizes 4 inch and larger, and valves of class 1500, sizes 3 inch and larger shall be equipped with hammer-blow wheels unless a valve operator is specified.

3.3.13.5 Toggle operators. Toggle operators shall be of the double toggle design and shall consist of 8 equal length toggle arms with the toggle arrangement being mounted on the valve yoke. Valve clamp ring shall not be a part of the valve yoke or toggle operator. Toggle design shall include a means of avoiding overstressing of the valve stem by providing ample stops to limit the stress applied to the valve stem. A means shall be provided to assure a constant seating load on the valve seats when the valve is in the closed position.

3.3.13.6 Power operators. Valves shall be designed to assure means of mounting c. ...rcial type power operators on the valve.

3.3.14 Seat leakage. Unless otherwise specified (see 6.2.1), allowable seat leakage is considered to be leakage of water not in excess of 10 cubic centimeters (cm^3) per hour per inch of nominal pipe size when tested in accordance with 4.6.5.2.

3.3.15 Lubrication. Yoke bushings 2-1/2 inches and larger shall be equipped with a 1/8-inch threaded or push designed, type III lubricating fitting in accordance with MIL-F-3541 and MS15001.

3.3.16 Welding and fabrication.

3.3.16.1 Welding. Welding shall be in accordance with MIL-STD-278.

3.3.16.2 Fabrication. Fabricated assemblies shall be stress relieved as units prior to finish machining. Stress relieving shall be done in accordance with MIL-STD-278.

3.3.17 Assembly and disassembly. Valve design and construction shall assure that assembly and disassembly of the valve can be accomplished onboard ship by Navy shipboard personnel without the need for special training or special tools. Special tools are defined as those tools not listed in the National Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Service (DCAS)). Design and external configuration shall be such as to permit the use of a portable boring machine to repair the bonnet inlay of the valve with the valve in place in the piping system.

3.4 Body markings and identification plates.

3.4.1 Body markings. Valve bodies shall have the class and manufacturer's name or trademark cast or forged integral with the valve body. Globe valves shall have a bridge wall marking in addition to the above markings. When necessary, metal stamping shall be permitted on the neck of the valve body or other similar areas not subjected to high stress in service.

3.4.2 Identification plates. Identification plates made of corrosion-resisting steel ...ses shall be permanently fastened to a part of the valve not subjected to working ...sure, preferably the yoke. Drawings of the proposed identification plates shall be reviewed by the procuring activity prior to their manufacture, and shall include the following data or a space therefor:

(a) Manufacturer's name or trademark.
(b) Size of valve and class.
(c) Stop check valve, if so constructed.
(d) Body and bonnet material composition.
(e) Valve trim identification (stem-disc-seat).
(f) Manufacturer's identification number (optional).
(g) Manufacturer's drawing number.
(h) MIL-V-22052.
(i) Component identification number (CID).
(j) National stock number (NSN).

3.5 Onboard repair parts. Onboard repair parts shall be as specified in table VI.

TABLE VI. Onboard repair parts.

Item	Quantities
Packings, gaskets, bonnet seal rings	50 percent of ship order but not less than two sets for each size, composition, and class
Valve disc and stem assembly	5 per...nt of ship order but not less than one complete set for each size, composition, and class

3.5.1 Repair parts (and special tools if required). When specified (see 6.2.1), re...ir parts (and special tools if required) shall be furnished in accordance with MIL-STD-1552 and MIL-STD-1561.

3.6 Technical data. The contractor shall prepare technical data in accordance with the data ordering document included in the contract or order (see 6.2.2), and as specified in 3.6.1 through 3.6.2.

3.6.1 Drawings. In addition to the drawing content required by the data ordering document (see 6.2.2), the following features shall be included:

(a) Accurately scaled sectional assembly which clearly depicts the design and construction of the valve.
(b) Bill of material listing specification, grade, condition, and any other data required to fully identify the properties of the materials proposed.
(c) Details of the seat, disc, and stem assembly and all other replaceable internal trim.
(d) Layout of the pressure-containing envelope (body and bonnet) giving dimensions which control compression of the spiral-wound gaskets and pressure seal ring. This is to assure that where remachining is necessary to repair the gasket-sealing surfaces on these parts, that compensating cuts can be accurately made to restore original gasket compression. This layout shall also specify the dimensional limits of such corrective remachining within which function of the valve remains unaffected.
(e) Recommended assembly torques, or equivalent procedures, for making up all joints and threaded assemblies.
(f) Tabulation of required gasket characteristics including all dimensions (with tolerances) and load versus compression characteristics (with tolerances).
(g) Mark areas to be radiographic, magnetic particle, or dye penetrant inspected.
(h) Dimensions-overall, accessibility space including disassembly clearances and all dimensions pertinent to installation.
(i) Surface finishes-show finish marks for all hard face surfaces and bearing areas.
(j) Name of laboratory conducting tests and date of previous successful shock and vibration tests.
(k) Welding procedure for seal canopy. Welding procedures shall include the following:

(1) Detail of weld.
(2) Welding process.
(3) Welding current (where applicable).
(4) Filler metal.
(5) Preparation.
(6) Interpass temperature.
(7) Technique.
(8) Post heat treatment.
(9) Provide a table listing size of weld, number of passes, electrode diameter, and welding characteristics.

3.6.1.1 Certification data. Certification data sheets shall be prepared by the contractor (see 6.2.2). In addition to the general requirements, the certification data sheets shall include the following:

(a) Class.
(b) Pressure and temperature rating.
(c) Body and bonnet material.
(d) Seat, disc, and stem material.
(e) Type of power operator, if required.
(1) Shock and vibration tests of valve with the power operator attached.

3.6.2 Manuals. In addition to the general requirements for technical manuals (see 6.2.2), the following shall be included as part of the contents:

(a) Drawings for the valve (including certification data sheet). Drawings shall be supplemented by additional illustrations where necessary to adequately illustrate operation and maintenance. These additional illustrations may consist of blowouts, partial or full sections, etc., and may eliminate extraneous lines and details to clarify the interaction of parts.
(b) Table listing wrench sizes and assembly torques (or other equivalent procedures) for making up all joints and threaded assemblies.
(c) Instructions to permit overhaul by shipyard or other repair facility. These should include procedures for checking all critical dimensions subject to wear or change and the acceptable dimensional limits, surface finish condition, etc. Also, the appropriate procedure (that is, part replacement, correction at repair facility, or repair at manufacturer's facility) which should be followed to correct each case of damage or wear.

(d) Detailed disassembly and reassembly procedures. In addition to providing procedures for the complete disassembly and reassembly of the equipment, maintenance and troubleshooting sections shall contain, or refer to, only the limited disassembly and reassembly required to accomplish each particular operation. This is intended to reduce the possibility of unnecessary disassembly and unnecessary disturbance of adjustments when performing specific or limited maintenance or troubleshooting operations.

(e) Adjustment procedures.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Inspection system program plan. The contractor shall provide and maintain an inspection system program plan in accordance with the data ordering document included in the contract or order (see 6.2.2).

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) Qualification inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 Qualification inspection. Qualification inspection shall be conducted at a laboratory satisfactory to the Naval Ship Engineering Center (NAVSEC). Qualification shall consist of the examinations and tests specified in 4.5 through 4.7.

4.3.1 Qualification inspection samples. Sample valves submitted for qualification inspection shall be of the 2-1/2 inch size, special class 1500, composition B. Valves of the 2-1/2-inch size, class 1500, composition B, which have passed the qualification tests will qualify valves in sizes 2-1/2 inches and larger of all compositions, classes 600, 900, 1500, and 2500, provided variations in design thoughout the various sizes and classes are demonstrated by analysis to be satisfactory to NAVSEC.

4.3.2 Authorization for qualification tests. Prior to authorization of qualification tests, the drawings specified in 3.6.1 shall be submitted to NAVSEC for review.

4.4 Quality conformance inspection. Each special class valve shall be examined and tested as specified in 4.5, 4.6.1, and 4.6.5. Each standard class valve shall be examined and tested as specified in 4.5, 4.6.1.4, and 4.6.5. The DCAS shall normally accept certification that materials comply with the specification, however, proof of compliance may be required by the DCAS.

4.5 Visual and dimensional examination. Valves shall be visually and dimensionally examined to verify compliance with the requirements of this specification not involving tests.

4.6 Tests.

4.6.1 Nondestructive testing.

4.6.1.1 Pressure containing castings of valves shall be 100 percent radiographically inspected when the service pressure or temperature will exceed the values listed in table VII. Inspection shall be in accordance with the following:

(a) Radiographic inspection shall conform to MIL-STD-271.
(b) Radiographic acceptance shall conform to MIL-STD-278.
(c) Radiographic coverage shall conform to the shaded areas shown on figures 2 and 3.

TABLE VII. Pressure or temperature criteria for nondestructive testing.

Service 1/	Gage pressure pounds per square inch (lb/in^2)	Temperature (°F)
Steam	225	500
Water	600	200
Oil	300	150

1/ When valves are used in services other than those listed, the criteria for nondestructive testing shall be as specified (see 6.2.1).

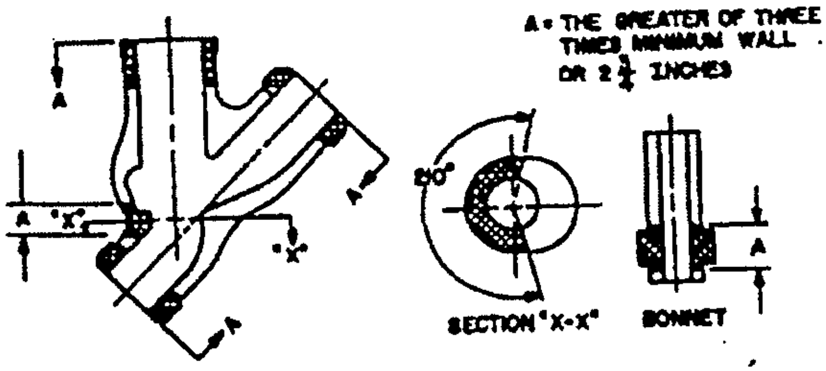
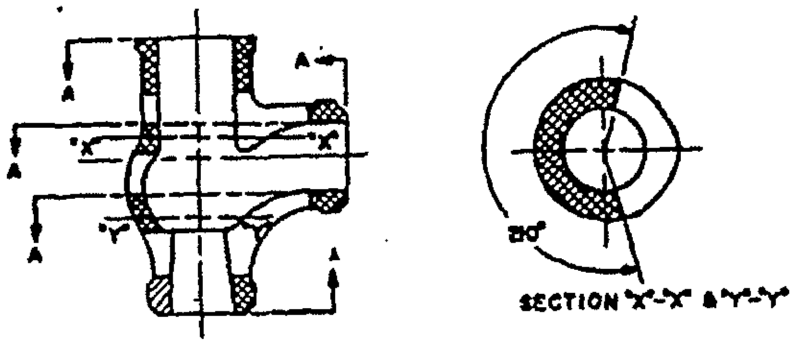


FIGURE 2. "Y" pattern globe body (pressure seal bonnet).



SH 11280

FIGURE 3. Angle body (pressure seal bonnet) bonnet same as "Y" pattern globe.

4.6.1.2 Pressure containing forgings of valves shall be 100 percent magnetic particle inspected in accordance with MIL-STD-271 when the service pressure or temperature exceeds the values listed in table VII. Forgings shall be free from flaws such as seams, cracks, laps, porosity, scale, flakes, and all other defects detrimentally affecting the suitability of the forging for the service intended.

4.6.1.3 Defects to be repaired. The following shall apply to those parts inspected in accordance with 4.6.1.1 and 4.6.1.2:

(a) Defects less than 0.030 inch in depth need not be repaired provided the bottom of the defect is rounded and visible and the minimum wall thickness is maintained.
(b) Defects greater than 0.030 inch in depth but less than 15 percent of the wall thickness shall be repaired by removing the defective material. This material shall be removed by drilling or grinding to a bottom radius of at least three times the depth of the defect. The depth of the finished repair shall be less than 15 percent of the undamaged wall thickness. Sharp corners shall be faired into the base metal. Welding is not required to effect a repair of this nature, provided the minimum wall thickness is maintained.
(c) Defects greater than 15 percent of the wall thickness shall be repaired by removing the defective material and welding. The material shall be removed by grinding or drilling and then welded in accordance with 3.3.16. The crown of the weld shall be blended into the base metal.

4.6.1.4 Hard faced seating. Hard faced seating surfaces shall be liquid penetrant inspected in accordance with MIL-STD-271 after rough machining and shall be free of cracks or crack-like/defects.

4.6.2 Cold tests. Cold tests shall be performed as follows:

(a) Operation - 10 cycles.
(b) Hydrostatic - shell and closure tests (see 4.6.5.1 and 4.6.5.2).

4.6.3 Hot tests. Hot tests shall be conducted with a gage pressure of 1200 lb/in^2 steam at 950°F and shall be performed in the following sequence:

(a) Thermal shock.
(b) Operation - 280 cycles.

4.6.3.1 Thermal shock tests. Valves shall be thermal shocked ten times by reducing the steam temperature from 950°F to 600°F in not more than 30 seconds.

4.6.3.2 Operational tests. Steam shall be passed through the valve for a period of not less than 48 hours. During this period two securing trials shall be made to determine if the valve remains tight while and after cooling to ambient temperature, and two warm-up trials shall be made to determine the torque required to open the valve which has been closed while cold. The valve shall be cycled a minimum of 280 times and the operating torque shall be recorded periodically during the cycling.

4.6.4 Shock and vibration. Valves shall be shock and vibration tested to determine conformance to the requirements specified in 3.3.9.

4.6.5 Hydrostatic tests. Valves shall be subjected to the tests specified in 4.6.5.1 for strength and porosity and the tests specified in 4.6.5.2 for tightness. Water temperature shall not exceed 100°F.

4.6.5.1 Shell test. Valves shall be given a shell test at a gage pressure no less than 1-1/2 times the 100°F rating, rounded off to the next higher 25 lb/in^2 increment. The test shall be made with water, which may contain a corrosion inhibitor, or with kerosene, or with other suitable fluid, provided such fluid has viscosity not greater than that of water, at a temperature not above 125°F. Visually detectable leakage through pressure boundary walls is not acceptable. Test duration shall be not less than as follows:

Valve size ips (inches)	Test time (seconds)
2-1/2 - 8	60
10 and larger	180

Test shall be made with the valve in the partially open position. Leakage through the stem packing shall not be cause for rejection.

4.6.5.2 Closure tests. Following the shell test, valves shall be given a closure test. Each valve 10 ips and larger, regardless of class and each valve in the size range ips 4 through ips 8, class 600 and higher shall be given a closure test using a fluid described in 4.6.5.1 at a pressure no less than 110 percent of the 100°F pressure rating. Each valve ips 4 through ips 8, class less than 600 and each valve in size less than ips 4, regardless of the pressure rating shall, be given either a fluid closure test at a pressure no less than 110 percent of the 100°F pressure rating or a gas closure test at a minimum gage pressure of 80 lb/in^2. The test pressure shall be applied successively on each side of the closed valve. Leakage rate of fluid test shall not exceed 10 cm^3, per hour per inch of nominal pipe size. Air test under water shall not allow the formation of a free air bubble. Duration of closure test shall be the same as specified in 4.6.5.1.

4.6.5.2.1 For globe and angle valves, the test pressure shall be applied across the closure member in the direction producing the most adverse seating condition. A stop check valve or other valve type designed to be a one-way valve, requires a closure test only in the appropriate direction.

4.6.5.2.2 Valves designed for operating conditions, that have the pressure differential across the closure member limited to values less than the 100 percent pressure rating and having closure members or actuating devices (direct, mechanical, fluid, or electrical) that would be subject to damage at high differential pressures, shall be tested as described above except that the closure test may be reduced to 110 percent of the maximum specified closed position differential pressure. This exception may be exercised upon agreement between the Navy and manufacturer. The manufacturer's nameplate data shall include reference to any such limitations.

4.7 Examination after qualification tests. Valves shall be disassembled and shall be visually and dimensionally examined for damage and wear. Disassembly and reassembly shall be performed to determine the practicability of maintaining a valve of this design for shipboard use (see 3.3.17). The maintainability demonstration shall be conducted by removing and replacing the pressure seal ring, disc, and stem. This shall be accomplished by following the instructions in the technical manual. Particular emphasis shall be directed towards the possibility of loss of small parts by the maintenance crew.

4.8 Inspection of preparation for delivery. Preservation-packaging, packing, and marking shall be inspected for compliance with section 5 of this document.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.4.)

5.1 Preservation-packaging, packing, and marking. Valves shall be individually preserved-packaged level A or C, packed level A, B, or C, as specified (see 6.2.1), and marked in accordance with MIL-V-3.

5.2 Repair parts and tools. Repair parts and tools shall be preserved-packaged, packed, and marked for the level specified (see 6.2.1) in accordance with MIL-R-196.

5.3 Cushioning, dunnage, and wrapping materials.

5.3.1 Level A preservation-packaging and levels A and B packing. Use of all types of loose-fill materials for packaging and packing applications such as cushioning, filler, or dunnage is prohibited for materials destined for shipboard installation/stowage.

5.3.2 Level C preservation-packaging and packing. When loose-fill type materials are used for packaging and packing applications such as cushioning, filler, and dunnage, all containers (unit, intermediate, and shipping) shall be marked or labelled with the following information:

"CAUTION

Contents cushioned etc., with loose-fill material.
Not to be taken onboard ship.
Remove and discard loose-fill material before shipboard stowage.
If required, recushion with cellulosic material, bound fiber, fiberboard, or transparent flexible cellular material."

5.3.3 Cushioning, filler, dunnage, and wrapping materials selected, whenever available, shall exhibit improved performance for resistance to fire.

6. NOTES

6.1 Intended use. Globe, angle, and Y pattern valves are intended for use in steam, water, and oil service.

6.2 Ordering data.

6.2.1 Procurement requirements. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Composition and rating required (see 1.2).
(c) End preparation (see 3.3.1).
(d) Size required (see tables II and III).
(e) Nonstandard sizes of drains and by-passes (see 3.3.4.1).
(f) Service conditions.
(g) Quantity required.
(h) Location of drains and by-passes (see 3.3.4.2).
(i) Boss requirements (see 3.3.4.4).
(j) Pattern required (see 3.3.5).
(k) Port arrangement on globe valves (see 3.3.6).
(l) Center of gravity location (see 3.3.7).

(m) Whether vibration test is required (see 3.3.5).
(n) Valve trim (see 3.3.12.5).
(o) Allowable seat leakage (see 3.3.14).
(p) Repair parts and special tools required (see 3.5.1).
(q) Criteria for nondestructive testing when valves are used in services other than as listed (see table VII).
(r) Level of preservation-packaging and packing required (see 5.1).
(s) Level of preservation-packaging and packing of repair parts and tools required (see 5.2).

6.2.2 Data requirements. When this specification is used in a procurement which invokes the provision of the "Requirements for Data" of the Armed Services Procurement Regulations (ASPR), the data identified below, which are required to be developed by the contractor, as specified on an approved Data Item Description (DD Form 1664), and which are required to be delivered to the Government, should be selected and specified on the approved Contract Data Requirement List (DD Form 1423) and incorporated in the contract. When the provisions of the "Requirements for Data" of the ASPR are not invoked in a procurement, the data required to be developed by the contractor and required to be delivered to the Government should be selected from the list below and specified in the contract.

Paragraph	Data requirements	Applicable DID	Option
3.6.1 and 3.6.1.1	Drawings, engineering and associated lists	DI-E-7031	Level 2 Design activity designation - Contractor Drawing Number - Contractor Delivery of hard copies - Procuring activity
3.6.2	Manuals	DI-M-2043	MIL-M-15071, type I
4.1.1	Inspection system program plan	DI-R-4803	---

(Copies of data items descriptions required by the contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.)

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the procuring/purchasing activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item procured to this specification. This does not apply to specific data which may be required for each procurement, regardless of whether an identical item has been supplied previously (for example, test reports).

6.2.2.2 Where the Government has limited rights in the data shown on the drawings, as determined by the contractual provisions regarding rights in technical data, the drawings may be marked with a legend. If used, the "Limited Rights Legend" of ASPR should be used.

6.3 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in applicable Qualified Products List QPL-22052 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Ship Engineering Center, Department of the Navy, Washington, DC 20362, and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.4 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in section 2 do not apply when material and parts are procured by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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4. TYPE OF ORGANIZATION (Mark one)

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- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER (Specify):

b. ADDRESS (Street, City, State, ZIP Code)

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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7a. NAME OF SUBMITTER (Last, First, MI) – Optional

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8. DATE OF SUBMISSION (YYMMDD)

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BUREAU OF SHIPS

MANUAL

CHAPTER 39

THERMAL INSULATION

NAVY DEPARTMENT,
Bureau of Ships,
1 April 1947.

This chapter is a revision of Bureau of Ships Manual, Chapter 39, "Thermal Insulation," dated 24 August 1945.

This revised chapter becomes effective upon receipt and shall be inserted in its proper place in the Manual binder.

E. W. MILLS,
Vice Admiral, U. S. N.,
Chief of Bureau.

Approved:
JAMES FORRESTAL,
Secretary of the Navy.

NAVSHIPS 250-000-39

Chapter 39

THERMAL INSULATION

CONTENTS

SECTION I—MACHINERY AND PIPING INSULATION

Part 1.—General

39-1. DEFINITIONS

(1) Insulating material is defined as the material employed to offer resistance to the flow of heat.

(2) Lagging is defined as the protective and confining covering or jacket placed over the actual insulating materials.

(3) Fastening is defined as the miscellaneous items with which insulating material is attached to the surface being covered and with which lagging is fixed to the insulating material.

(4) Insulation is defined as the composite covering including insulating material, lagging, and fastening.

39-2. REASONS FOR INSULATING

(1) In every power plant there is a heat loss from all heated surfaces and a heat flow to all cooled surfaces. Heat flow may occur in three ways; by conduction, by convection, and by radiation.

(2) Conduction is the heat flow from one part of a body to another part of the same body, or from one body to another with which it is in physical contact, without displacement of the particles of the body. This manner of heat flow is most important in insulation as it is the low conduction which results in the greatest temperature differential between a hot insulated surface and the atmosphere (as in steam piping insulation), or the relatively warm atmosphere and a cold surface (as in refrigerating plant insulation). Heat transfer from insulated pipes or large blanketed or cemented surfaces (turbines, evaporators, etc.) to the outer surface of their lagging is included in this mode. Conduction is associated with solids and comparison of materials in this respect is measured by a factor called the "thermal conductivity" which expresses rate of conductivity in British thermal units (B. t. u.) per inch of thickness per hour per square foot of area per degree Fahrenheit temperature differential.

(3) Convection is the transfer of heat from one point to another within a fluid, gas, or liquid, by circulating or mixing of one portion of the fluid with another. These currents are produced by warm fluid being displaced by heavier cold fluid. It is of interest to note that convection reduces the effectiveness of air space insulation unless such space is very small.

(4) Radiation is the method of heat transfer by which a hot body gives off energy in the form of radiant heat which is emitted in all directions. Radiant heat, like light, travels in straight lines and with the speed of light. The surface condition greatly affects the ability of a body to radiate heat. Dull, dark, rough finished surfaces are the best radiators. Conversely, bright, shiny, smooth surfaces are good heat reflectors.

(5) In order to minimize the transfer of heat from or to a body or surface which is hotter or colder, respectively, than the surrounding atmosphere, thermal insulation is applied. This thermal insulation

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is a material or materials of low thermal conductivity. (See par. 39-2 (2).) While increasing the economy of the plant, thermal insulation also reduces the quantity of air necessary for ventilating and cooling requirements and prevents injury of personnel due to burns from contact with hot parts of apparatus. It also insures more uniform heat distribution within equipment. Another function of thermal insulation is to prevent "sweating" of cold surfaces on which atmospheric moisture condenses thus causing undesirable dripping as well as accelerated corrosion of the metal. Insulation must be sufficiently effective to reduce heat losses and lower surface temperatures to a degree which will permit habitable conditions in a specific space or compartment.

Part 2.—Materials

39-11. INSULATING MATERIALS

(1) The following requirements should be met as nearly as possible by thermal insulating materials:

(*a*) Low heat conductivity.

(*b*) Noncombustibility.

(*c*) Lightweight.

(*d*) Capability of easy molding and application.

(*e*) Moisture repellent.

(*f*) Noncorrosive, insoluble, and chemically inactive.

(*g*) Composition, structure, and characteristics anged by temperatures at which it is to be

(*h*) Once installed, should not cluster, become lumpy, disintegrate or build up in masses from vibration.

(*i*) Vermin proof.

(2) Insulating materials are available in the following forms in accordance with Navy Department Specifications:

(*a*) Molded sectional pipe covering:

Thermal insulation pipe covering	32P8
Molded cork (with fire resisting compound) pipe covering	32P11

(*b*) Block:

Thermal insulation block	32I3

(*c*) Batts, blankets and felts:

Roll asbestos felt	32F1
Asbestos insulating felt	32F3
Fibrous glass batt insulation	32I1
Mineral wool blanket insulation	32I2
Mineral wool pipe covering for low temperature	32I5
Thermal insulating tape	32T1

(*d*) Plastic:

High temperature insulation cement	32C14
Magnesia plaster	32P10

(3) Thermal insulation pipe covering, Spec. 32P8, grade I, usually is 85 percent magnesia and it is suitable for temperatures from 100° up to 500° F. Eighty-five percent magnesia is a molded product formed from a combination of 85 percent magnesium carbonate with about 15 percent asbestos fiber for strength and bond. It is made in standard and light density (classes a and b) which weigh 16 and 12 pounds per cubic foot, respectively. The standard weight material is used mostly; it is harder, stronger (in rupture) and less affected by heat than the light grade, but it is about 25 percent poorer in insulating value. The pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. Larger sizes are furnished in quadrant or segmental form. Sections which become broken may be reused as plastic cement by breaking up the material and mixing it with water.

(4) Thermal insulation pipe covering, Spec. 32P8, grade II, class c, is a fibrous product usually formed from a uniform mixture of asbestos fibers (composed mostly of pure silica and the oxides of iron and magnesium) and held together with a sodium silicate (water glass) binder. Its average density is 13.5 pounds per cubic foot. It is considerably harder than either of the magnesia materials in paragraph 39-11 (3) and comparable to the standard magnesia covering as a good insulator. It is resilient, tough, and withstands vibration. It has a smooth, brown, finished surface. Molded asbestos saws and cuts neatly with ordinary tools. It can be used for temperatures up to 750° F. and is manufactured in cylindrical sections 3 feet long, split in half lengthwise. Class d under grade II of Spec. 32P8 covers compounded materials. These are products which have been developed comparatively recently and which vary in composition. Grade II materials are suitable for temperatures up to 750°.

(5) Thermal insulation pipe covering, Spec. 32P8, grade III, class e, is a compounded material usually consisting of molded diatomaceous earth. It consists of practically pure silica blended and bonded with asbestos fibers. It is used in a single layer for insulating piping up to and including 1½ inches nominal size. For piping 2 inches and over in size, the insulation is in the form of combination pipe covering, the inner layer of which contacts the hot surface and is diatomaceous earth. The outer layer is 85 percent magnesia of the type described in paragraph 39-11 (3). This class of material is suitable for temperatures from 501° up to 900° F.

(6) Thermal insulation pipe covering, Spec. 32P8, grade III, class f, is a fibrous material usually consisting of asbestos similar to that described in paragraph 39-11 (4), but it is much harder and withstands high temperatures. It is used in a single layer for insulating piping up to and including 1½ inches nominal size. For piping 2 inches and over in size, the insulation is in the form of combination pipe covering, the inner layer of which contacts the hot surface and is high temperature material. The

outer layer is class c material. This pipe covering is available as combined sections with the two classes formed together to give the appearance and workability of a uniformly molded material. The average density is 17.5 pounds per cubic foot in the single layer and 16 pounds when used in the combination form. This material is suitable for temperatures from 751° to 900° F.

(7) The description herein of materials covered by Spec. 32P8 is based on materials as procured and their naval applications. All the common pipe covering materials have been discussed. As newly developed products are found to be suitable for naval use, such pipe coverings probably will be installed in addition to the common materials.

(8) Molded cork pipe covering, Spec. 32P11, is composed of cork joined by and coated over with a vapor-sealing compound. The pipe covering sections are made of pure granulated cork compressed into molds and held together by the natural cork gum as a binder. The fire retardant vapor-sealing compound is composed of chlorinated resins, drying oils, dryers, and fillers. A volatile solvent is added to attain the necessary fluidity for easy application with a stiff brush or trowel. At the time of installation the untreated molded cork insulating material is coated on all surfaces with the vapor seal. Each delivery of cork includes sufficient copper-clad steel wire and vapor seal for complete application. The molded cork is available in the following types: Ice water thickness, brine thickness, and special brine thickness. Pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. Cork covers for elbows, T's, valves, etc. are available. This material is of low thermal conductivity, high structural strength, almost free from shrinkage, resists moisture penetration when thoroughly coated, and acts as a good insulating material for refrigeration service.

(9) Thermal insulation block, Spec. 32I3, is furnished in 3 classes according to the allowable temperatures for which the materials are suitable. Class A of the specification covers insulating material for temperatures up to 500° F. These blocks usually are made of 85 percent magnesia or asbestos with characteristics as described in paragraphs 39–11 (3) and 39–11 (4), respectively. The maximum density for this class is 15 pounds per cubic foot. Block insulation is flat and rectangular. Asbestos block should be used where unusually high resistance to compression is required.

(10) For class B of Spec. 32I3, temperature range of 501° to 1,000° F., high temperature molded asbestos of the composition described in paragraph 39–11 (6) can be used. Diatomaceous earth high temperature insulating material in molded block form also is available for this service. It is described in paragraph 39–11 (5).

(11) For the higher range of temperatures, 1,001° to 1,500° F. covered by class C of Spec. 32I3, diatomaceous earth material in block form is used.

(12) Roll asbestos felt, Spec. 32F1, is composed of medium long asbestos fiber and organic sizing. The materials are felted into sheets, with an indented surface, of such flexibility that it may be folded, bent, or wrapped around piping and equipment. It is furnished in rolls ⅛ or ¼ inch thick and 3 feet wide. The ¼-inch roll weighs about 1.2 pounds per square foot. This material is suitable for temperatures up to 900° F.

(13) Asbestos insulating felt, Spec. 32F3, is furnished in type A, plain, and type B, water repellent for cold piping. Plain felt is composed of asbestos fibers and cotton and binding materials if required. Water-repellent felt is composed of asbestos fibers, cotton treated with a suitable repellent agent, and a cotton fabric encasement. Asbestos felt has a maximum density of 12 pounds per cubic foot. Plain asbestos felt is furnished in rolls 50 feet long by 60 inches wide and in thicknesses of ¾, 1, and 1½ inches. It has perhaps the widest range of uses of the insulating materials as it has flexibility for fitting around valves or other irregular surfaces and it is suitable for a temperature range from cold water to 900° F. Water-repellent asbestos felt is furnished in rolls 50 feet long and in widths from 3 to 60 inches; thicknesses are ¾ or 1 inch.

(14) Fibrous glass batt insulation, Spec. 32I1, is composed of glass fibers bonded together to form a semirigid batt. The fibrous glass is pure glass in fibrous form and is inorganic and fireproof and resistant to salt water and some chemical actions. It cannot mildew, decay, or provide sustenance to insects, rodents, or vermin. The batts are furnished in two grades, one weighing 6 pounds per cubic foot and the other 4.5 pounds. Standard dimensions are 48 inches long by 24 inches wide by 1 to 3 inches thick. When this material is used at elevated temperatures, the binding agent burns out at a point between 450° and 600° F. Hence, batts should be enclosed by sheet steel for support when subjected to temperatures between 450° and 900° F. The material is suitable for insulating boiler uptakes.

(15) Mineral wool blanket insulation, Spec. 32I2, consists of fibers from slag, glass, or limestone made by a process of melting, blowing, or drawing, and annealing. The blankets are felted and reinforced by wire netting or metallic lathing on both sides. The material is suitable for use at temperatures up to 900° F.

(16) Mineral-wool pipe covering for low temperatures, Spec. 32I5, is composed of mineral-wool fibers felted into strip form encased in fire-resistant fabric. The pipe covering is furnished in sections 3 feet long and made to such a width that when laterally folded around a given size of pipe, a reasonably tight uniform covering results.

(17) Thermal insulating tape, Spec. 32T1, is composed of a woven asbestos jacket enclosing either an asbestos fiber or fibrous glass felting or sliver. The jacket is woven from yarn of asbestos fiber; it may be either in one tubular piece or fabricated of asbestos cloth sewed into tubular form. The tape is supplied in two forms, one for spiral wrapping and the other for lateral wrapping. That for spiral wrapping is 2 to 2½ inches wide and ¼ to ⅜ inch thick. The tape for lateral wrapping is 5¼ inches wide and ⅜ inch thick. It is suitable for temperatures up to 750°.

(18) High temperature insulation cement, Spec. 32C14, is available in two types. Type A is the diatomaceous earth or exfoliated mica type and is composed of a dry mixture of suitable grades of such refractory material ground fine, asbestos fibers, and clay binders, thoroughly mixed to obtain uniform distribution of the ingredients. Type B is the rock or mineral-wool type which consists of a dry mixture of rock or mineral-wool fibers, asbestos fibers, and binders, thoroughly mixed to obtain uniform distribution of the ingredients. This latter type is most suitable for monolithic insulation. The composition of the cement is such that when properly wetted with fresh water, it can be applied with a trowel or by hand to hot and cold surfaces. One hundred pounds of dry cement will cover 50 square feet of surface to a thickness of 1 inch. After application it weighs a maximum of 30 pounds per cubic foot. The cement is reclaimable for reuse. The thermal conductivity of this material is higher than the nonplastic materials. All cements covered by Spec. 32C14 are suitable for use at temperatures from 100° to 1,000° F., and some may be used for 1,800° F. service. It is very important that all rock or mineral-wool type cements which may be used shall have corrosion-resisting properties conforming to the specification.

(19) Magnesia plaster, Spec. 32P10, is a mixture of not less than 85 percent long-fiber asbestos. The plaster is supplied dry and when properly tempered with water, it can be laid on with a trowel or by hand to form a light, incombustible, porous, heat-insulating covering. The material has the characteristics of 85 percent magnesia pipe covering described in paragraph 39-11 (3). Magnesia plaster will adhere to cold metal only with difficulty and it will not adhere to hot metal. One hundred pounds of the material covers about 67 square feet of surface to a thickness of 1 inch. The density after being molded and dried is not more than 16 pounds per cubic foot. Magnesia plaster may be used for temperatures from 100 to 500° F. Cements of the types described in paragraph 39-11 (18) are better for all purposes except for finishing insulation to a very smooth surface.

39-12. LAGGING MATERIALS

(1) The definition of lagging in paragraph 39-1 (2) describes the purpose of this item. It protects the relatively soft insulating material from mechanical abuse to which it is exposed aboard ship as a result of men climbing over piping and the necessary handling of equipment. It supports the insulating material which is subjected to continual vibration. The lagging provides a smooth finish to be painted.

(2) Materials in accordance with the following Navy Department Specifications are used as lagging:

(*a*) Cloth:
- Asbestos cloth, strands and tape 32C11
- Cotton duck pipe covering 24D3
- Fibrous glass cloth, tape and thread (for lagging insulation) 32G9

(*b*) Paper:
- Asbestos paper and tape reinforced with cotton mesh 32P9
- Flameproof and water - repellent sheathing paper 59P7

(*c*) Board:
- Asbestos millboard 32M1

(*d*) Plastic:
- Asbestos insulation finishing cement 32C16

(*e*) Metallic:
- Zinc coated (galvanized) sheet steel 47S29

(3) Asbestos cloth, strands, and tape, Spec. 32C11, are made of good quality asbestos yarn or combination of asbestos and glass yarn and contain no rubber or other filling materials except cotton fiber. The types of cloth and tape are classified by the maximum allowable cotton content. Type A cloth and type G tape are intended for use as the lagging material for insulation on pipe or tubing at all temperatures; it is not to be used on valves, fittings, and flanges if it will be in contact with heated metal. It may be used on valves, fittings, and flanges where the temperature of the insulated surface is 500° F. or less, and for temperatures over 500° F. on applications such as butt-welding end fittings where it is desirable to lag the fittings with the material used on the tubing. A blue stripe is woven into the finished edge of this material which may be asbestos or combination of asbestos and glass yarn. The remaining types do not contain glass yarn. Type B, 90 percent asbestos cloth, is furnished with a red stripe woven in and is intended for use as the outside lagging on removable and replaceable covers for flanges and fittings or other applications on valves, fittings, and flanges where the temperature of the insulated surface is more than 500° F. Ninety-five percent asbestos cloth is furnished with or without wire insertion. That with the wire, type C, is intended for use as the inside lagging on removable and replaceable covers for valves, flanges, and fittings at all temperatures. The wire adds to the strength and stiffness of the lagging. Type D, 95 percent asbestos cloth without the wire, is intended for the same conditions as type C when strength and stiffness is not necessary. This material is furnished

with a green stripe woven into the finished edge. An 80 percent asbestos sewing thread and a 95 percent yarn reinforced with wire are available under the specification.

(4) Fibrous glass cloth, tape, and thread, Spec. 32G9, are manufactured from a good quality of fibrous-glass yarn. The tapes and cloths are made in various weights and weaves, the most frequently used being described herein. Tight, satin-weave, lightweight cloth is recommended for straight pipe. For irregular surfaces, tight, broken-twill weave, heavyweight cloth should be used. Medium, plain weave, lightweight tape in 2- to 6-inch widths is suitable for curved pipe in particular. Tapes are applied with a minimum amount of labor and time. The sewing thread is a twisted specially treated cord. *Fibrous glass materials are not recommended for use where lagging is exposed to mechanical injury.* The material may be used for lagging surfaces with internal temperatures up to 900° F., but should not be used on removable and replaceable covers nor where it will be in contact with hot metal surfaces.

(5) Canvas or cotton duck, Spec. 24D3, has been widely used as a lagging material. Unlike asbestos and glass, duck is flammable and should be used only for service in the cold range of 36° to 99° F. Duck should not be used if glass cloth or asbestos cloth is available.

(6) Asbestos paper and tape reinforced with cotton mesh, Spec. 32P9, is composed of approximately 75 percent asbestos, 8 percent organic binder, and 17 percent cotton netting. This material is suitable for temperatures up to 500° F. It does not stand much abuse and is recommended for use only if glass or asbestos cloth is not available.

(7) Sheathing paper, Spec. 59P7, is made in three types. The flameproof and water-repellent paper does not support combustion and absorbs only the specified small weight of water. The two other types of paper have but one of the aforementioned characteristics. This material is used in conjunction with other lagging; see the instructions for insulation of cold water piping in part 4. The paper is supplied in rolls 36 inches wide.

(8) Asbestos millboard, Spec. 32M1, is composed of asbestos fiber and binding material formed under pressure into a sheet. It has a fair amount of insulating value for temperatures up to 400° F. but is mostly used as outside lagging on removable insulating covers to which it gives stiffness. It is available in thicknesses of from ⅛ to ½ inch in sheets the standard size of which is 42 by 48 inches. The maximum acceptable weight is 6.5 pounds per square foot of material 1 inch thick.

(9) Asbestos finishing cement, Spec. 32C16, is composed of asbestos fibers, fillers, and suitable binders thoroughly mixed to obtain a uniform distribution of the ingredients. The composition is such that when properly wetted with fresh water, it can be readily troweled to a smooth surface. One hundred pounds of cement has a covering capacity, applied and dried, of 19 square feet 1 inch thick. About 100 pounds of water is required to mix 100 pounds of cement. Asbestos cement is used as a surface finish over insulating material to seal all joints and provide a hard, smooth finish to which lagging is applied.

(10) Galvanized sheet steel, Spec. 47S29, is used as described in the sections on application of insulation.

39-13. ADHESIVE MATERIALS

(1) Adhesives which comprise one type of fastening as defined in paragraph 39-1 (4) are covered by the following Navy Department Specifications.

Fibrous adhesive insulation cement----	52C22
Adhesive and sealing cements--------	52C23
Sodium silicate solution (33.5° Baumé)-	51S29

(2) Fibrous adhesive, Spec. 52C22, is suitable for securing woven asbestos cloth to insulating material employed on piping or other applications. The cement is ready for use without heating or addition of other ingredients, except that it may be furnished in the unmixed form to be mixed just prior to use. It will not deteriorate for an indefinite length of time when enclosed in airtight metal containers. When used for fixing lagging or insulating materials to other than metal surfaces, 75 pounds of adhesive will cover about 100 square feet. Adhesive cement per Specification 52C22 must never be used for securing fibrous glass cloth or insulation since it causes disintegration of such materials. Therefore, this cement is not to be used with type A cloth or type G tape per Spec. 32C11.

(3) Adhesive insulation cement per type B of Navy Department Specification 52C23 is suitable for securing all lagging materials. It has the best properties of the adhesives described herein. Cements in accordance with the specification will not corrode steel when applied thereto.

(4) Sodium silicate solution, Spec. 51S29, may be used for fastening asbestos cloth. The cloth, when soaked in the silicate of soda and applied to the surface, molds into position and dries to form a hard, firm finish which resists abrasion. The remarks in paragraph 39-13 (2) in regard to the use of fibrous adhesive cement with fibrous glass materials apply also to sodium silicate solution.

Part 3.—Application of Thermal Insulation
General

39-21.

(1) Cloth and paper lagging should be covered with one coat of fire-retardant paint, per Bureau of Ships Spec. 52P22, after installation. The inside covers of removable blanket insulation need not be painted. Canvas lagging, if used, should be given

e coat of canvas preservative per Spec. 52C26 of color to suit the adjacent bulkheads or decks.

(2) All steampiping, valves, and fittings located in positions exposed to the weather or to salt water spray should be insulated and lagged watertight with sheet metal. Where it is not feasible to apply insulation, paint the piping with heat- and weather-resistant paint, and install suitable guards to protect personnel. Also use metal lagging where necessary to shield the insulation from damage. Metallic lagging, galvanized sheet steel, may be painted for appearance with one coat of zinc chromate primer, formula 84, followed by one coat of fire-retardant paint per Bureau of Ships Spec. 52P22.

(3) Where the detailed instructions which follow hereafter do not specifically cover any surface requiring insulation, such surface should be insulated in a manner similar to the requirements covering a condition which most nearly approximates that of the surface in question.

(4) At least once a year and preferably at 6-month intervals, a careful inspection should be made of insulation. All broken or loose insulating or lagging materials should be securely fastened in accordance with instructions herein. If much material is broken, a complete reinstallation is recommended.

(5) In the course of emergency repairs as a result of damage, insulation is to be stripped from piping in flooded compartments if practicable. This procedure will prevent serious corrosion of piping by insulation which carries a large amount of water even subsequent to unwatering operations.

(6) The following tables indicate various approved insulating, lagging, and fastening materials to be used and minimum thicknesses required for all services and temperature ranges.

TABLE I

Service	Temperature conditions (°F.)	Pipe or tubing		Valves and fittings	
		Insulating materials	Lagging	Insulating materials	Lagging
Superheated steam and exhaust gases.	751 to 900	32P8, grade III; 32T1	32C11, type A and G; 32G9.	32C11, type B; 32F3, type A; 32I3, class b; 32P8, grade III.	32C11, type A, B, C, D, and G; 32G9.
Do.	501 to 750	32P8, grade II and III; 32T1.	32C11, type A and G; 32G9.	32C14, type B; 32F3, type A; 32I3, class b; 32P8, grade II and III.	32C11, type A, B, C, D, and G; 32G9.
Saturated steam, exhaust gases, hot water, and hot fuel oil.	100 to 500	32P8, grade I and II; 32T1.	32C11, type A and G; 32G9; 47S29.	32C14, type B; 32F3, type A; 32I3, class a; 32P8, grade I and II.	32C11, type A, B, C, and G; 32G9.
Cold water	32 to 99	32F3, type A and B; 32I5.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; 32I5.	32C11, type A and G; 32G9; 59P7.
Refrigerant	36 and over	32F3, type A and B; 32I5; 32P11, type A.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; 32I5; 32P11, type A.	32C11, Type A and G; 32G9; 59P7.
Do.	0 to 35	32P11, type B	32C11, type A and G; 32G9.	32P11, type B	32C11, type A and G; 32G9.
Do.	Below 0	32P11, type C	32C11, type A and G; 32G9.	32P11, type C	32C11, type A and G; 32G9.

Service	Temperature conditions (°F.)	Flange joints		Machinery	
		Insulating materials	Lagging	Insulating materials	Lagging
Superheated steam and exhaust gases.	751 to 900	32F3, type A; 32I3, class b; 32P8, grade III.	32C11, type C and D	32C14, type B; 32F3, type A; 32I2; 32I3, class b.	32C11, type A, B, C, D, and G; 32G9.
Do.	501 to 750	32F3, type A; 32I3, class b; 32P8, grade II and III.	32C11, type C and D	32C14, type B; 32F3, type A; 32I2; 32I3, class b.	32C11, type A, B, C, D, and G; 32G9.
Saturated steam, exhaust gases, hot water, and hot fuel oil.	100 to 500	32C14, type B; 32F3, type A; 32I3, class a; 32P8, grade I and II.	32C11, type A, B, C, and G; 32G9.	32C14, type B; 32F3, type A; 32I2; 32I3, class a.	32C11, type A, B, C, and G; 32G9.
Cold water	32 to 99	32F3, type A and B; 32I5.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B	32C11, type A and G; 32G9; 59P7.
Refrigerant	36 and over	32F3, type A and B; 32I5; 32P11, type A.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; HH-C-561.	32C11, type A and G; 32G9; 59P7.
Do.	0 to 35	32P11, type B	32C11, type A and G; 32G9.	HH-C-561	32C11, type A and G; 32G9.
Do.	Below 0	32P11, type C	32C11, type A and G; 32G9.	HH-C-561	32C11, type A and G; 32G9.

TABLE II.—*Compounded insulating material thicknesses for hot pipe or tubing*

Pipe size (inches)	Temperature range (°F.)	Class of material per Spec. 32P8: Inner layer	Class of material per Spec. 32P8: Outer layer	Thickness (inches): Inner layer	Thickness (inches): Outer layer	Thickness (inches): Total
½ and ¾	100-388	a, b, or d		¾		¾
	389-500	a or		1¼		1¼
	389-500	b or d		1¼		1¼
	501-750	d or		1 13/16		1 13/16
	501-750	e		1 13/16		1 13/16
	751-900	e		¾		¾
1	100-388	a or		1 5/16		1 5/16
	100-388	b or d		1¼		1¼
	389-500	a or		1½		1½
	389-500	b or d		1½		1½
	501-750	d or		1 13/16		1 13/16
	501-750	e		1 13/16		1 13/16
	751-900	e		¾		¾
1¼	Same materials and thicknesses as ½-inch size.					
1½	100-388	a or		1 5/16		1 5/16
	100-388	b or d		1¼		1¼
	389-500	a or		1¼		1¼
	389-500	b or d		1¼		1¼
	501-750	d or		1 13/16		1 13/16
	501-750	e		1 13/16		1 13/16
	751-900	e		1½		1½
2 and 2½	100-338	a, b, or d		2		2
	339-388	a or		1¾		1¾
	339-388	b or d		3		3
	389-500	a, b, or d		3		3
	501-750	d or	a or b	1¼	1 13/16	3 1/16
	501-750	e	a or b	1¼	1 13/16	3 1/16
	751-900	e		1½		1½
3	100-338	a, b, or d		2		2
	339-388	a or		1¾		1¾
	339-388	b or d		3		3
	389-500	a, b, or d		3		3
	501-750	d or	a or b	1½	2	3½
	501-750	e	a or b	1½	2	3½
	751-900	e		1½		1½
3½	100-338	a or		1¾		1¾
	100-338	b or d		2		2
	339-388	a, b or d		3		3
	389-500	a, b or d		3		3
	501-750	d or	a or b	1¼	1 13/16	3 1/16
	501-750	e	a or b	1¼	1 13/16	3 1/16
	751-900	e		1½		1½
4	100-338	a, b or d		2 3/16		2 3/16
	339-388	a or		1¾		1¾
	339-388	b or d		3		3
	389-500	a, b, or d		3		3
	501-750	d or	a or b	1½	2	3½
	501-750	e	a or b	1½	2	3½
	751-900	e		1½		1½
4½	100-338	a or		1¼		1¼
	100-338	b or d		2 3/16		2 3/16
	339-388	a or		2		2
	339-388	b or d		3		3
	389-500	a, b or d		3		3
	501-750	d or	a or b	1¼	1 13/16	3 1/16
	501-750	e	a or b	1¼	1 13/16	3 1/16
	751-900	e		1½		1½
5	Same materials and thickness as 4-inch size.					
6	Do.					
7	100-338	a, b or d		2½		2½
	339-388	a or		2½		2½
	339-388	b or d		3		3
	389-500	a, b or d		4		4
	501-750	d or	a or b	1½	2	3½
	501-750	e	a or b	1½	2	3½
	751-900	e		1½		1½
8, 9, and 10	100-338	a, b, or d		2½		2½
	339-388	a or		2½		2½
	339-388	b or d		3		3
	389-500	a, b, or d		4		4
	501-750	d or	a or b	2	2	4
	501-750	e	a or b	2	2	4
	751-900	e		1½		1½
11	100-338	a, b, or d		3		3
	339-500	a, b, or d		4		4
	501-750	d or	a or b	2	2	4
	501-750	e	a or b	2	2	4
	751-900	e		1½		1½
12 and over	100-338	a, b, or d		3		3
	339-500	a, b, or d		4		4
	501-750	d or	a or b	2	2	4
	501-750	e	a or b	2	2	4
	751-900	e				

NOTE.—Temperature of saturated steam at 25 p. s. i. gage is 267° F.
Temperature of saturated steam at 100 p. s. i. gage is 338° F.
Temperature of saturated steam at 200 p. s. i. gage is 388° F.

TABLE III.—*Fibrous insulating material thicknesses for hot pipe or tubing*

Pipe size (inches)	Temperature range (° F.)	Class of material per, Spec. 32P8: Inner layer	Class of material per, Spec. 32P8: Outer layer	Thickness (inches): Inner layer	Thickness (inches): Outer layer	Thickness (inches): Total
½ through 1½	100-388	c		¾		¾
	389-500	c		1½		1½
	501-750	c		2		2
	751-900	f		2		2
2 through 3½	100-338	c		1½		1½
	339-388	c		2		2
	389-500	c		2½		2½
	501-750	c		3		3
	751-850	f	c	1½	2	3½
	851-900	f	c	1¾	1½	3¼
4 through 6	100-338	c		1½		1½
	339-388	c		2		2
	389-500	c		2½		2½
	501-750	c		3		3
	751-850	f	c	1½	2	3½
	851-900	f	c	2	1½	3½
7 through 11	100-338	c		1½		1½
	339-388	c		2 3/16		2 3/16
	389-500	c		2½		2½
	501-750	c		4		4
	751-850	f	c	1½	2½	4
	851-900	f	c	2	2	4
12 and over	100-338	c		1½		1½
	339-388	c		2¾		2¾
	389-500	c		2¾		2¾
	501-750	c		4		4
	751-850	f	c	1½	2½	4
	851-900	f	c	2	2	4

TABLE IV.—*Thicknesses of insulating materials in inches for cold water and refrigerant pipe and tubing flanges, valves and fittings*

Pipe size (inches)	Service	Temperature range (° F.)	Molded cork, Specification 32P11	Asbestos felt, Specification 32F3; types A or B	Mineral wool, Specification 32I5
Up to ¾	Refrigerant	Below 0	2.60		
	do	0 to 35	1.70	1½	1¼
	do	36 and over	1.20	1	1¼
	Cold water	All			
1 and 1¼	Refrigerant	Below 0	2.75		
	do	0 to 35	2.00	1½	1½
	do	36 and over	1.30	1	1½
	Cold water	All			
1½ to 5½	Refrigerant	Below 0	2.95		
	do	0 to 35	2.40	2¼	3
	do	36 and over	1.35	1	1½
	Cold water	All			
6 and 7	Refrigerant	Below 0	4.00		
	do	0 to 35	2.40	2¼	3
	do	36 and over	1.35	1	1½
	Cold water	All			
8 to 12	Refrigerant	Below 0	4.00		
	do	0 to 35	3.00	2¼	3
	do	36 and over	1.35	1	1½
	Cold water	All			
Over 12	Refrigerant	Below 0	4.00		
	do	0 to 35	3.00	2¼	3
	do	36 and over	1.50	1	1½
	Cold water	All			

TABLE V.—*Thicknesses of insulating tape per Spec. 32T1 for hot piping ¼- and ⅜-inch size*

Temperature range (° F.)	Thickness of tape (inches)	Number of layers	Total thickness (effective)
100-338	¼	1	3/16
339-388	½	1	½
389-500	¾	1	¾
501-750	½	2	1
751-900	1 and ¼	1 of each	1

TABLE VI.—*Thicknesses of insulating materials for hot surfaces of machinery*

Temperature range (° F.)	Asbestos felt, block, or mineral wool blanket	Cement (Spec. 32C14, type B)
100–338	1½	1½
339–398	2½	2½
399–500	3	3
501–750	3½	4
751–900	4½	5

Part 4.—Application of Thermal Insulation to Pipe or Tubing

39–31. TEMPERATURES FROM 501° TO 900° F.

(1) Piping systems with temperatures over 500° F. include superheated steam piping and Diesel exhaust piping. Thermal insulation pipe covering, per Spec. 32P8, classes e or f, is used for services from 501° to 900° F. and is described in paragraphs 39–11 (5) and 39–11 (6). The thickness of pipe covering should be as shown in table II, which covers compounded insulating material or table III, which covers fibrous insulating material.

Single layer molded pipe covering is applied directly on the piping. Side and end joints should be tightly butted. Sections are securely fastened in place with 18-gage (0.049 inch diameter) nickel-copper, brass, or galvanized soft iron wire or metal bands. Use three loops or bands per length of insulating material on pipes up to and including 6 inches and four loops or bands on larger pipes. The ends of the wire loops are fastened together to hold the insulating material tightly against the pipe. The wire ends are bent over and carefully pressed into the pipe covering to leave no projection. Joints, cracks, or indentations in the surface of the insulating material are pointed up with high temperature insulating cement (Spec. 32C14) or asbestos finishing cement (Spec. 32C16). In double layer work both the longitudinal and circumferential joints of the second layer are staggered in relation to the first layer and both layers are secured as previously described. The outer layer may be pointed up with magnesia plaster if the insulating material is 85 percent magnesia.

Thermal insulating tape as described in paragraph 39–11 (17) is specially suitable for small piping and where space conditions render awkward the use of molded covering. The tape also is suitable for bends. Tape for spiral wrapping should be wired at each 10 inches approximately. Tape for wrapping laterally must be wired at each end of every strip. Thicknesses are shown in table V. The lagging should be type A or G asbestos cloth or tape or glass cloth or tape.

(2) *Bends.*—Where bends are encountered in the piping, the sectional insulating material is cut or mitered as shown in Figures 39–1, 39–2, and 39–3 to fit neatly around the contour of the bend. Care must be taken to insure that each segment is securely fastened in place. All openings and crevices are filled with high temperature cement, Spec. 32C14, or asbestos finishing cement (Spec. 32C16), troweled smoothly to a uniform surface. Sharp bends may be insulated with asbestos insulating felt per paragraph 39–11 (13) overlaid with ½ inch of high temperature insulating cement or asbestos finishing cement (Spec. 32C16) finished off smoothly.

39–32.

(1) *Application of glass cloth and tape.*—Glass cloth per paragraph 39–12 (4) is fitted on tight and smooth and sewed with fibrous glass sewing thread using a single stitch, three to the inch. Glass cloth and tape may be cemented on with adhesive cement per paragraph 39–13 (3). In general, tape rather than cloth is used for lagging pipe bends. Fibrous glass tape is applied in a spiral wrapping around the pipe. At the start the tape may be stapled to the insulating material or secured with an adhesive. On straight runs, a ¼-inch lap is sufficient. The tape may be furnished with a stripe woven in as a guide for lapping. On bends, the lap should be made at right angles to the axis of the pipe. A new roll of tape is started as if it were to be wrapped in the reverse direction and attached with staples or adhesive. The tape then is brought back over the fastening which thus is concealed from view. Where pipes are located close together, the tape may be applied easily by wrapping it on a smooth rounded edge metal "shuttle." The tape is fastened to the insulating material and the shuttle passed between the pipes, picked up on the far side, and the tape pulled tight.

(2) *Application of asbestos cloth.*—Asbestos cloth is fitted on tight and smooth. It may be sewed with asbestos yarn or may be cemented on. Adhesive cement per paragraph 39–13 (2) can be used to fasten asbestos cloth other than type A. Cements described in paragraph 39–13 (3) are suitable for all materials. The surfaces to be joined must be dry and clean. Apply the adhesive to the cloth, not to the insulating material. The more rough and porous the surface may be, the more adhesive will be needed. Asbestos cloth, except for type A, also may be fastened on with sodium silicate solution described in paragraph 39–13 (4). The cloth should be soaked in the solution and the insulating material given a liberal painted coat of the same. The lagging is applied while the surface is still wet.

39–33. DIESEL ENGINE EXHAUST FLEXIBLE CONNECTIONS

The connections may be insulated by one of the following methods:

(a) In accordance with paragraphs 39–31 (1) and 39–31 (2) provided the flexible connection is cov-

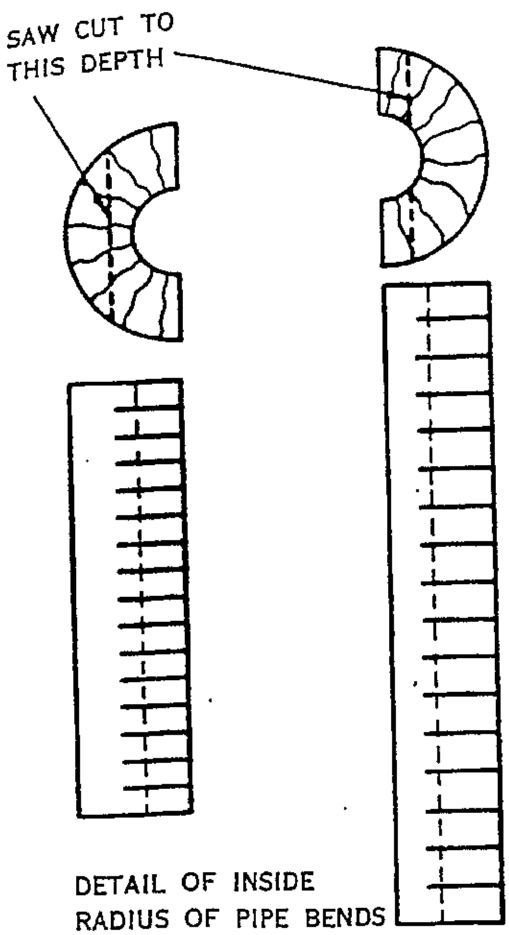

Figure 39-1.—Detail of outside radius of pipe bends.

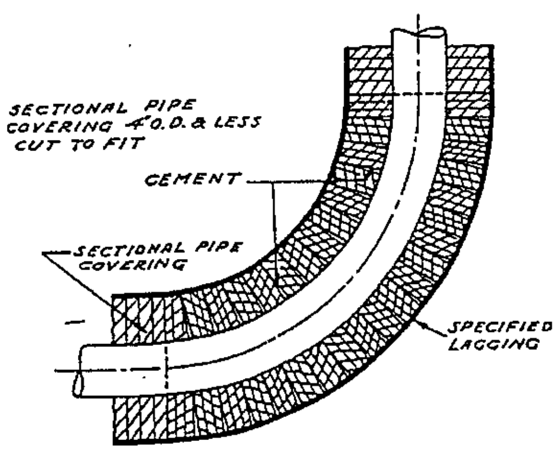

Figure 39-2.

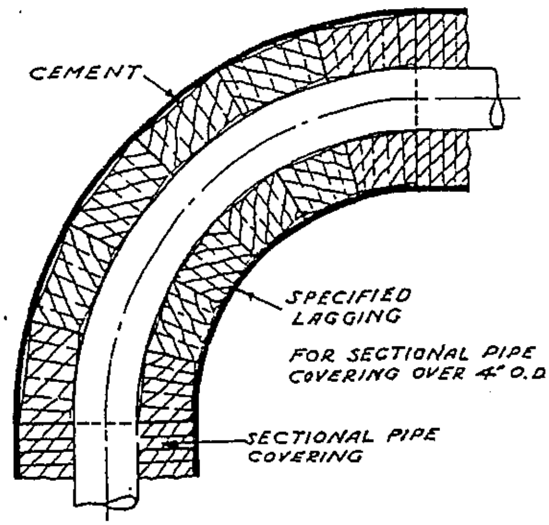

Figure 39-3.

ered with 1-inch galvanized wire mesh before application of the insulating material.

(b) Apply asbestos insulating felt per paragraph 39-11 (13) overlaid with a layer of asbestos paper which is described in paragraph 39-12 (6). Lag in accordance with paragraph 39-31 (1).

39-34. BULKHEAD EXPANSION JOINTS

Continue the insulation under the connection with the pipe covering butting each side of the flange which secures the joint to the piping.

39-35. PIPE HANGERS

Where pipe hangers are clamped around the piping, the sectional pipe covering may be stopped at the clamp and the space filled with layers of asbestos felt per paragraph 39-11 (13) to the thickness of the covering. A single layer of asbestos cloth which extends over the sectional covering 2 inches on either side is wrapped circumferentially over the felt and is secured by wire through rings and hook fasteners to form a take-down seam. A similar covering may be used on flanges to which are welded anchor lugs for pipe hangers. Hangers may also be insulated by fitting the molded pipe covering as necessary; use insulating cement to complete the installation.

39-36. TEMPERATURES FROM 100° TO 750° F.

(1) For temperatures between 100° and 750° F., thermal insulation pipe covering, Spec. 32P8, classes c or d may be used. The thickness of pipe covering should be as shown in table II or III. This material is applied in the manner described in article 39-31. Lagging may be in accordance with paragraphs 39-32 (1) or 39-32 (2).

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39–37. TEMPERATURES FROM 100° TO 500° F.

(1) For temperatures between 100° and 500° F., thermal insulation pipe covering, Spec. 32P8, classes a and b, described in paragraph 39–11 (3) is used. Also see article 39–36. Lagging may be in accordance with paragraphs 39–32 (1) or 39–32 (2). If asbestos or glass cloth is not available, asbestos paper, which is described in paragraph 39–12 (6), may be used. The thickness of the pipe covering should be as shown in table II.

39–38. APPLICATION OF REINFORCED ASBESTOS PAPER OR TAPE

Asbestos paper or tape per Spec. 32P9 is generally used in the 36-inch sheet form on straight runs of piping although spiral wrapping with narrower widths of tape will give a satisfactory job. Use tape for fittings and bends. Asbestos tape should always be applied with the guide line on the outside. Do not apply asbestos paper or tape over wet cement. Apply cold water paste with a brush or sponge to pipe insulation before wrapping with asbestos paper or tape. If preferred, the paste or adhesive cement can be applied directly to the sheet material.

(1) *Paper:* Paste and/or staple the inner edge to the top of the insulating material and carry the paper around the pipe and paste on the outside edge lapping over a minimum of 2 inches. Paper can either be terminated at fittings, with tape applied thereto, or continued around fittings, mitering the inside lap, and molding in place by hand to give a continuous uniform appearance. Asbestos paper can be sewed in a manner similar to asbestos cloth when it is used on straight runs of pipe. After sewing, smooth down the edge with a sponge and water or cold water paste.

(2) *Tape:* Use the material dry. Start the application by fastening the tape to the insulation with a staple or paste. The guide line must be on the outside. Apply one wrap double thick to start and cover the staple, if used; then spiral the tape on overlapping each layer a minimum of ½ inch as indicated by the guide line. After spiral wrapping, smooth out irregularities in laps by applying water with a sponge to all spiral joints. Apply water at joints to change direction of wrapping when necessary to give a smooth appearance.

39–39. COLD WATER AT ALL TEMPERATURES

Three insulating materials may be used on cold water pipe or tubing.

(1) Asbestos insulating felt should be applied to thoroughly cleaned and dried pipe surfaces in the thicknesses shown in table IV. The material is described in paragraph 39–11 (13).

The felt is applied in ¾-inch layers which are compressed to ½-inch thickness by 18-gage nickel-copper, brass, or galvanized soft iron wire wound on about 1 inch centers. Joints in adjacent layers of felt are staggered longitudinally and radially. Water-repellent asbestos felt in strip form is applied longitudinally; the width is such as to enclose the circumference of the pipe. The following table gives pipe sizes and widths of felt which have been extensively used for these sizes:

Width (inches):	*Pipe sizes (inches)*
5	½ and ¾
7	1 and 1¼
9	1½ and 2
13	2½ and 3
16	3½ and 4
21	4½, 5, and 5½

The asbestos felt is covered with one layer of water-repellent and flameproof sheathing paper which is described in paragraph 39–12 (7). The paper should be tightly wrapped and lapped 3 inches each way. On bent piping the sheathing paper is mitered and fitted tightly. Joints must be sealed completely with adhesive cement (N. D. Spec. 52C23, type B). The lagging may be asbestos cloth per paragraph 39–32 (2) or glass cloth per paragraph 39–32 (1). Cotton duck described in paragraph 39–12 (5) may be used if the former materials are not available. The lagging should be cemented on with material per paragraph 39–13 (3).

(2) Mineral-wool pipe covering described in paragraph 39–11 (16) is suitable for low temperatures. The material is furnished in 1½-inch thickness only. It is applied similarly to the manner described in paragraph 39–39 (1).

(3) Molded-asbestos pipe covering (Spec. 32P8, class C), which is described in paragraph 39–11 (4), may be used for cold water lines if felt is not available. Apply sheathing paper and lagging in accordance with paragraph 39–39 (1).

39–40. REFRIGERANT

(1) Molded cork pipe covering described in paragraph 39–11 (8) is used in the thicknesses shown in table IV. See article 39–39 for other materials suitable for refrigerant at temperatures of 36° F. and over.

(2) At the time of installation, the fire-retardant vapor seal may be applied to the cork in the following manner: The inner surfaces of the semicylindrical sections of cork are heavily coated with the compound by brushing and allowed to dry at room temperature for 24 hours. The longitudinal surfaces and ends of each section of the covering are then coated with the compound and the sections are immediately installed, butted together longitudinally, and secured. In the installation of the sections, excess compound which is forced out of the longitudinal joints may be doctored off. The external surface of the covering is then given a brush coat of the compound which is allowed to dry for 48 hours.

(3) Pipes must be free from rust and moisture before applying insulation. Sectional covering should be applied with end joints broken by starting with one half- and one full-length piece. Longitudinal joints should be at the top and bottom of the pipe. Wire the sections in place with at least six copper-clad wires per 36-inch section. When the pipe passes through an insulated wall into a refrigerated room, the pipe covering should extend into the room 1 inch beyond the wall. Pipe bends are insulated by mitering regular sectional covering to fit the bend, using pieces small enough to give approximately full contact between the pipe and the covering. Pipe hangers must be on the outside of the covering and not in contact with the pipe. Frost will collect around the supporting rod of a hanger attached directly to the pipe and will eventually work under and split off the covering at that point. A 12- to 18-gage galvanized sheet-steel shield should be used between the hanger and covering where the pipe rests in the hanger. The shield should extend at least 3 inches on each side of the hanger. Glass or asbestos cloth or tape lagging should be applied in accordance with paragraphs 39-32 (1) or 39-32 (2), respectively.

Part 5.—Application of Thermal Insulation to Valves, Fittings, and Flanges

39-51.

Permanently insulated valves and fittings should be covered to the same total thickness as the adjacent piping. Valves and fittings which are welded into the line are insulated permanently. Flanged valves and flanged fittings may have permanent or removable type insulation. Where the pipe covering is terminated at flanges, provision must be made for removal of the flange bolts or bolt-studs. The pipe insulation may be stopped off squarely and a short removable section of insulating material of sufficient length to permit the withdrawal of the bolting may be inserted. A less desirable method is to omit the short removable section of insulation by terminating and beveling off the pipe covering at the necessary distance from the flange.

39-52. COVERS

Readily removable and replaceable covers should be provided on the following piping elements requiring insulation:

(1) Flanged joints (except valve bonnet joints) on all sizes of main and auxiliary steam piping carrying steam having a total temperature of 389° F. (205 p. s. i. saturated steam) and over, including flanged joints on all root connections and root valves thereon, such as valve bypasses, drain connections, pressure gage connections, etc.

(2) Flanged joints on piping and adjacent to machinery units which must be broken when these machinery units are opened for inspection and overhaul, such as steam exhaust connections, feed pump suction and discharge connections, steam drain connections, etc.

(3) Valve bonnets on all valves over 2 inches in size, working pressure of 300 p. s. i. and over, carrying fluids 240° F. and over.

(4) Pressure reducing and pressure regulating valves, pump pressure governors, and strainer bonnets.

39-53. METHODS OF MAKING COVERS

Readily removable and replaceable covers for piping elements are made by the following methods:

(1) Rigid covers made in two halves filled with asbestos felt are shown in figures 39-4 and 39-5. Covers are sewn and quilted with wire inserted asbestos yarn (Navy Department Spec. 32C11, type E) in such a manner as to provide a uniform thickness. Wire inserted asbestos cloth (Navy Department Spec. 32C11, type C) is used on the inside of the covers to provide strength and rigidity. Asbestos cloth (Navy Department Spec. 32C11, type B) is used on the outside surface of the cover if the temperature of the insulated surface does not exceed 500° F. For temperatures over 500° F. asbestos cloth (Navy Department Spec. 32C11, type D) is used on the outside of the cover. Flexible asbestos millboard, ⅛ inch thick, is inserted between the asbestos felt and the asbestos cloth so as to retain the cylindrical shape of the cover. Hard asbestos millboard, ¼ inch thick, enclosed in asbestos cloth of the type used on the outside of the cover is sewn on the ends of the cover. Where the flange diameter is larger than the outside diameter of the adjacent pipe-covering, build-up pieces are made of asbestos felt encased in asbestos cloth (Navy Department Spec. 32C11, type D) secured by stitching to the inside of the cover. The halves of the cover may be fastened around the equipment by means of $^1/_{16}$ inch diameter soft galvanized iron rope laced through brass or galvanized steel hooks or rings, or covers may be secured by snap fasteners. Fastenings fixed to cloth lagging must be backed up by washers on both sides of the cloth.

(2) A rigid cover made up of segments of block insulation of the same material used for pipe covering is shown in figure 39-6. Block is securely wired to frames of ½ inch square mesh of 18 gage (0.049 inch diameter) galvanized steel wire. The wire mesh frames inside and outside of the block insulation have the ends bent over and joints secured with 18-gage, black-annealed, iron wire woven through the mesh. Insulating cement of the same material as the blocks is trowelled smoothly over all surfaces of the mesh. Asbestos roll fire felt (Navy Department Spec. 32F1) may be used to build up the cover where the flange diameter is larger than the outside diameter of the adjacent pipe-covering. Covers should be lagged with asbestos cloth (Navy Department Spec. 32C11, type D) tightly and smoothly fitted to envelop the outside and ends.

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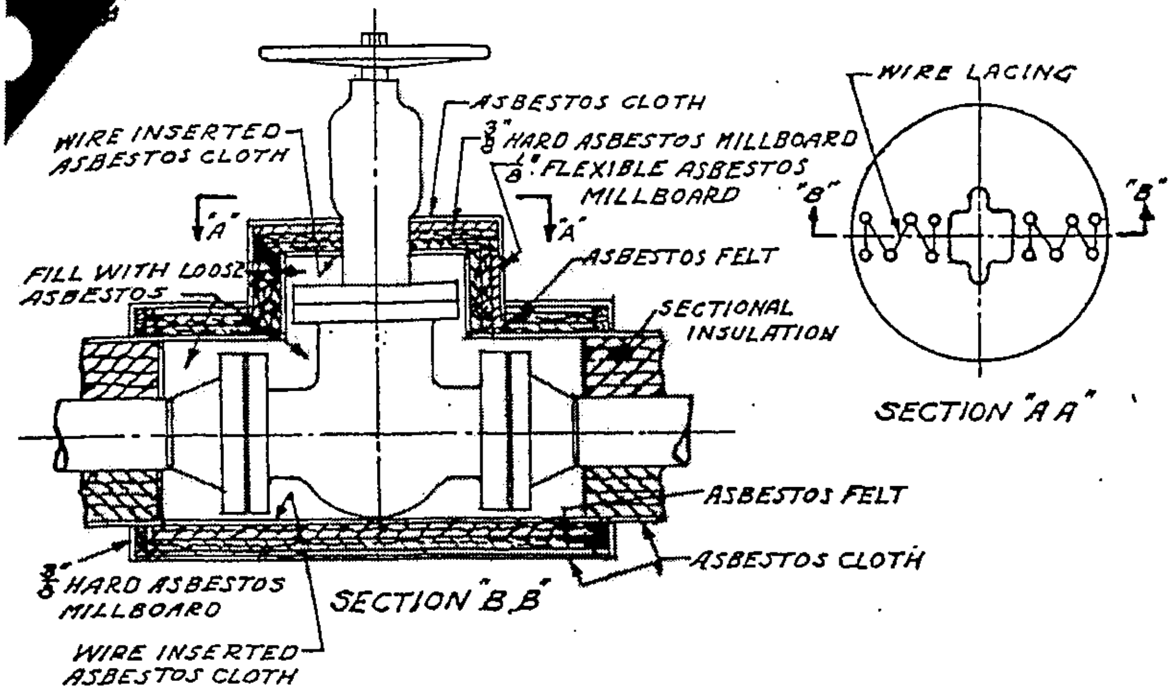

FIGURE 39–4

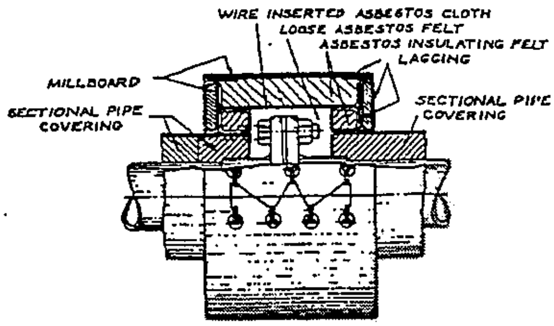

FIGURE 39–5

Lagging may be secured with an approved high temperature adhesive cement.

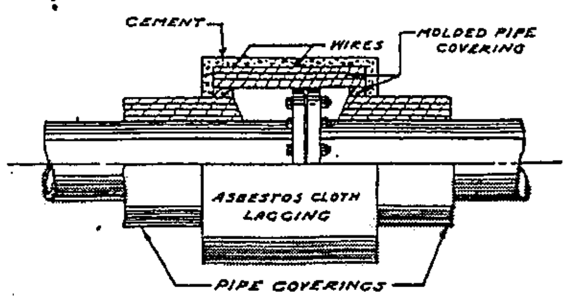

FIGURE 39–6

Where double layer insulation is used, the two sections of the cover should be fitted together with a scarfed joint. Care must be taken in the workmanship to insure straight and true jointing surfaces of the sections with the view of reducing the heat loss at the joints. Bands and eyelets of galvanized steel are used for securing the cover around the equipment.

(3) Rigid covers similar to those described in paragraph (2) above may be made of fibrous sectional pipe-covering (Navy Department Spec. 32P8, classes C and F) of the same thickness as that on the adjacent piping. The pipe-covering is strong enough so that the wire frames are not required.

(4) Where the rigid covers described above are not practical, for example because of restricted space, flexible covers, as shown in Figure 39–7, may be used. These covers are similar to those described in paragraph (1) above except that the millboard is omitted.

(5) Flexible flange covers shown in figure 39–8 may be made as described below:

(a) A circular wooden form is first made up with a diameter equal to the flange diameter for which the particular cover is going to be made.

(b) The inner and outer covering of the flange covers are made of asbestos cloth. The inner cloth is laid over the form and accurately cut to the length

required with allowance for stitching so that the finished inside surface will be smooth and free from wrinkles.

(c) The end pieces of the cloth are cut circular to suit inside and outside diameters with the necessary allowance for stitching. The cloth cut in this form will eliminate puckers and wrinkles.

39–54.

Spaces between removable covers and the surfaces they insulate should be packed with pieces of asbestos felt to exclude all air possible. On covers which do not fit tightly about the adjacent pipe covering, spaces should be calked with suitable material such as narrow strips of asbestos cloth.

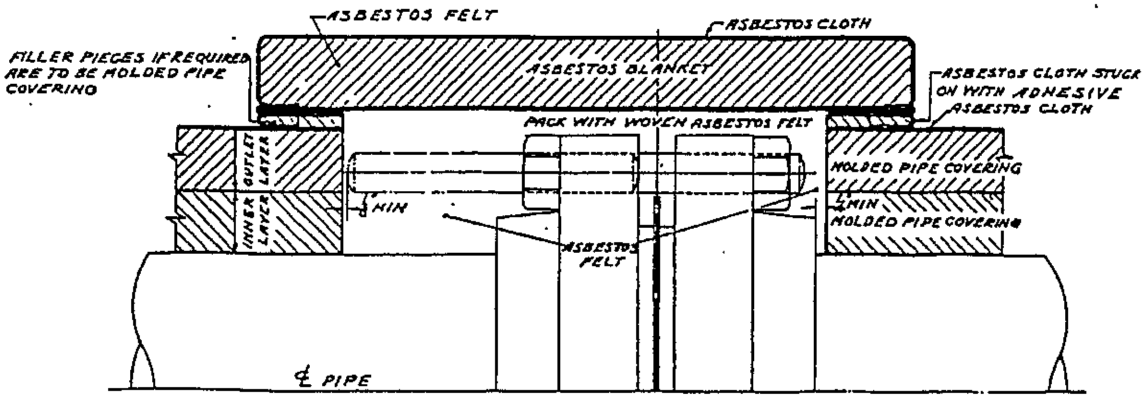

FIGURE 39–7

(d) The outside cloth covering is cut in the same manner as described in (b) above.

(e) The pieces of cloth are sewn together before filling with asbestos felt as much as it is practical to do so. Stitching is done from the inside where possible in order to improve the external appearance.

(f) Before filling the cover with asbestos felt, a 3/16-inch diameter steel rod is inserted along the entire length of the outside lap of the joint. The rod is secured in place by stitching with asbestos sewing thread. This rod provides a straight hard edge at the outside of the lap, thus providing a greatly improved appearance and serving to hold the shape.

(g) A stiffener strip, which consists of asbestos cloth of the same type used for the outside covering, is placed under the outside covering; its width should extend far enough to include the lacing washers and rings. The strip is well soaked in silicate of soda or adhesive cement and allowed to dry prior to insertion in the cover. The strip will be reasonably rigid but flexible enough to bend to the curvature of the cover. This piece of cloth serves to stiffen the surface of the cover in way of the lacing rings, washers, and wire and eliminates the corrugations caused by them.

(h) The overlap is made to reduce the heat loss at the joint. It allows additional flexibility for drawing the ends of the cover together and provides a margin to take care of any difference in diameter that may occur.

39–55

The foregoing description of the use of removable covers is applicable to the latest construction. Existing installations need not be changed simply to conform to these requirements but changes made only when replacement is necessary.

39–56

Valves, fittings and flanges not included in article 39–52 may have permanent insulation; the following applies to temperatures of 100° F. and up:

(a) For sizes 3½ inches and under, an all cement insulation may be used. Apply insulating cement, usually in accordance with Navy Department Spec. 32C14, type B, in ½ to ¾ inch thick layers to cover the bodies, flanges, and bonnets. Each layer of cement must be permitted to dry before the next is applied. Heat should be applied from within as soon as practicable and within 24 hours after installation of the cement to dry out the insulation and avoid corrosion of the metal. After drying, a coating ½ inch thick of high temperature cement tempered with Portland cement or equal (4 parts cement to 1 part Portland cement) or a coating of asbestos finishing cement per Navy Department Spec. 32C16 is applied and trowel-rubbed to a smooth finish. Lagging should be in accordance with paragraphs 39–12 (3) or 39–12 (4). For temperatures from 100 to 500° F., magnesia plaster, Navy Department Spec. 32P10 described in paragraph 39–11 (19), may be used in lieu of high temperature insulating cement; however, this material is less strong and is more difficult to apply.

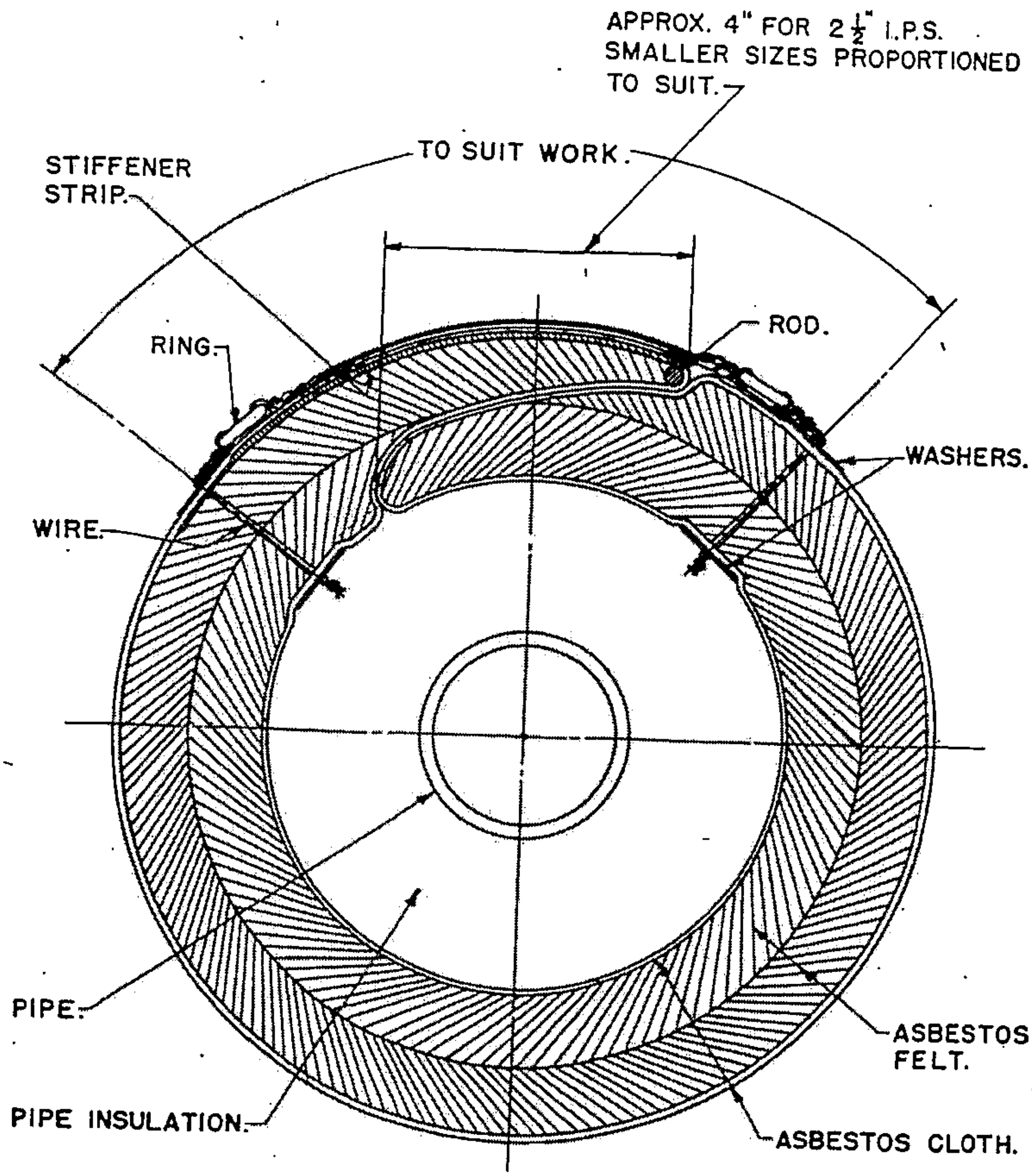
APPROX. 4" FOR 2½" I.P.S.
SMALLER SIZES PROPORTIONED
TO SUIT.
TO SUIT WORK.
STIFFENER
STRIP.
RING.
ROD.
WASHERS.
WIRE.
PIPE.
ASBESTOS
FELT.
PIPE INSULATION.
ASBESTOS CLOTH.

FIGURE 39-8.

(b) A method similar to that of paragraph (a) above but having a form of wire-reinforced asbestos cloth, Navy Department Spec. 32C11, type c, over which the cement is applied is shown in figure 39–9. Spaces around the bolts should be packed with asbestos felt.

(c) All sizes may be insulated by cutting asbestos felt, per type A of Navy Department Spec. 32F3, in suitable widths and building up the thickness required to match the adjoining pipe covering allowing for ½ inch of finishing cement. On valves and fittings the felt should be carried over the flanges to the end of the sectional pipe covering. Spaces that cannot be filled with the layers of material should be completely filled with loose asbestos felt. Fix the first layer of asbestos to the metallic surface with adhesive cement, preferably of the type described in paragraph 39–13 (3). Layers of felt are secured in position with black or galvanized iron wire and overlaid with 1-inch-square wire mesh. A ½-inch layer of cement as described in paragraph (a) above is applied. Lagging should be in accordance with paragraphs 39–12 (3) or 39–12 (4). See figure 39–10.

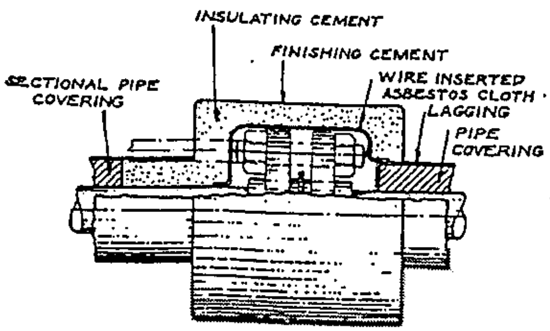

FIGURE 39–9.

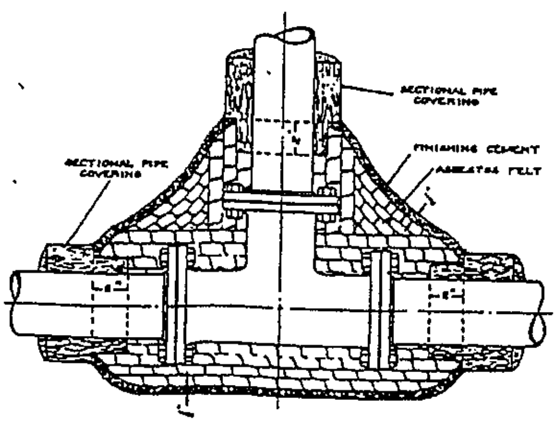

FIGURE 39–10.

39–57

Valve bodies and fitting bodies may be permanently insulated as described in paragraph 39–56 (c) but the felt is not carried over the flanges; the latter are insulated with removable covers.

39–58. COLD WATER AT ALL TEMPERATURES

Valves, fittings, and flanges for cold service do not have removable covers because the insulation must be tight against the penetration of moisture. The following methods are used:

(a) Insulate in a manner similar to that described in paragraph 39–56 (c) using either plain or water-repellent asbestos felt per Navy Department Spec. 32F3. Wire should be galvanized. Felt need not be covered with finishing cement. Place a layer of water-repellent and flame-proof sheathing paper, which is described in paragraph 39–12 (7), over the felt; paper should be mitered, lapped, and fitted carefully. Use adhesive cement per type B of Navy Department Specification 52C23 to secure and seal the paper. Lagging should be the same as used on the cold pipe; see paragraph 39–39 (1).

(b) Insulate as described in paragraph (a) above but use mineral wool pipe covering instead of asbestos felt.

39–59 REFRIGERANT

For temperature of 36° F. and over the methods described in article 39–58 or molded cork may be used. Below 36° F. molded cork valve, fitting, and flange covers must be used for insulating refrigerant lines. Covers should be of the same thickness as adjacent pipe insulation. For the most generally used sizes, valve and fitting covers are furnished in two sections. The method of application outlined in paragraph 39–40 is used. Sections of cork covering made for pipes should not be mitered to form makeshift covers for elbows or other fittings. Flanged fitting covers are applied after covering has been installed on the piping and rest upon the outside of the pipe covering. For other than flanged fittings, the covers are wired on first and the straight pipe insulating material is wedged in tightly between the fittings. To make the cork fit properly, cut the straight pipe covering rather than the fitting covers. Make cuts square to secure tight joints. Carefully wire the covers in place using not less than four 12-gage, copper-clad, steel wires for each soldered fitting, and not less than six wires for each flanged fitting. Cement filler and putty used in commercial application of cork insulation must not be used because such materials are flammable.

Part 6.—Application of Thermal Insulation to Machinery

39–71. RECIPROCATING ENGINES

(1) Propulsion reciprocating engine steam cylinders, valve chests, and other steam enclosing sur-

faces are insulated with 85 percent magnesia or asbestos blocks which are described in paragraph 39–11 (9). High-pressure cylinders and valve chests should have insulation 3 inches thick applied in two 1½-inch layers. For intermediate pressure cylinders and valve chests, use 2 inches of insulating material and for low-pressure cylinders and valve chests use 1 inch. The blocks should be carefully fitted to the metallic surface. Where there are two layers, all joints should be staggered. The blocks should be firmly fastened in place with ⅛-inch galvanized steel cables spaced on 9-inch maximum centers. 1-inch mesh, galvanized, wire netting of 18-gage wire is then spread over the surface and held by wiring to the steel cables. All joints should be neatly pointed and smoothed with magnesia cement per paragraph 39–11 (19) or high temperature cement per paragraph 39–11 (18), and a layer just thick enough to cover the netting and tie wires completely should be trowelled on smoothly. Cylinders and valve chests are neatly lagged all over with 24-gage, galvanized, sheet steel per paragraph 39–12 (10). Upper cylinder heads are insulated as described above but are arranged with cast-iron plates with nonslip upper surfaces instead of sheet-metal lagging. Metal lagging may be secured by using lap joints with a bead on the exposed edge, fastened with hardened self-tapping screws making their own thread in punched holes. See figure 39–11.

(2) Auxiliary reciprocating engines may be insulated as described in paragraph 39–71 (1). Asbestos felt per paragraph 39–11 (13) may be used in place of blocks if it is considered more practicable.

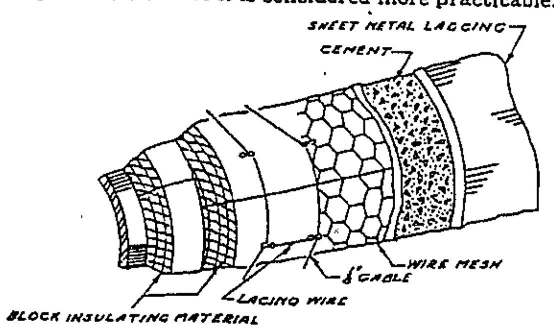

FIGURE 39–11

39–72. TURBINES

All surfaces of propulsion and auxiliary turbines which have a maximum operating temperature of 100° F. or more should be insulated by one of the methods described in this section. Thickness of insulating material should be as shown in table VI.

(1) Surfaces which can be permanently insulated may be covered with sufficient layers of asbestos felt per paragraph 39–12 (13) to make up the required thickness. Joints of adjacent layers should be staggered. Layers of felt may be held to one another with adhesive cements per paragraphs 39–12 (2) and 39–12 (3). Felt should be firmly secured with ⅛-inch, flexible, galvanized, steel cable spaced on 9-inch maximum centers around the outside layer. The cable may be fastened to steel hooks welded to the casing where required. No holes should be drilled in the casing. One-inch mesh netting of 18-gage, galvanized, steel wire is spread over the felt and secured by 18-gage wire to the cables. A ½-inch thick coating of finishing cement (32C16) or of insulating cement per paragraph 39–11 (18) tempered with Portland cement or equal (4 parts insulating cement to 1 part Portland cement) is applied over the netting and trowel rubbed to a smooth finish. After drying 24 hours, an adhesive insulation cement per paragraphs 39–12 (2) or 39–12 (3) is applied to the hard cement finish and allowed to dry for 1 hour, after which a second coat of the same cement is applied and allowed to dry. Lag the insulation with glass cloth or asbestos cloth of the correct type indicated in paragraph 39–13 (3). Galvanized steel rings backed up by galvanized steel washers fastened on both sides of the lagging should be attached to the permanent insulation adjacent to removable blankets. These blankets are used to cover the flange joint between the upper and lower casings. They are formed by quilting layers of asbestos felt together with fine nickel copper alloy or brass wire or asbestos twine per paragraph 39–12 (3). The turbine side of the blanket is covered with wire-inserted asbestos cloth and the outer surface is covered with plain asbestos cloth of the type recommended in paragraph 39–12 (3).

Blankets are secured to the permanent insulation with 18-gage, galvanized iron or copper wire laced through metal hooks or eyes attached to the edges of the blankets and the rings on the permanent insulation. It is preferable that blankets should project well over the insulation of the adjacent surface. Blankets should be shaped to fit accurately, and spaces between them and the hot metallic surfaces should be completely filled with loose asbestos. (See fig. 39–12.)

(2) Another method is to use the same procedure outlined in paragraph (1) above with mineral wool blanket insulation per paragraph 39–11 (15) instead of asbestos felt for both permanent and portable insulation. Removable blankets made with mineral wool should be covered with ¼-inch of asbestos roll felt per paragraph 39–11 (12) previous to enclosing them with asbestos cloth.

(3) Thermal block insulation per paragraphs 39–11 (9) and 39–11 (10) may be used for permanent insulation. Prior to applying the block, all irregularities of the turbine surface should be filled to form a smooth surface. Use magnesia or preferably high temperature cement for temperatures below

500° F. and high temperature insulation cement for higher temperatures. Magnesia plaster or insulation cement should be used to point up joints between the layers of block and all crevices should be filled. The block covering is held in place by ⅛-inch, flexible, galvanized steel cable spaced on 9-inch maximum centers. The cable may be fastened to steel hooks welded to the casing where required. One-inch mesh netting of 18-gage, galvanized steel wire is spread over the outer layer of block and secured by 18-gage wire to the steel cables. Finishing cement and lagging are applied as described in paragraph (1) above. Removable insulation also is the same as outlined in that paragraph.

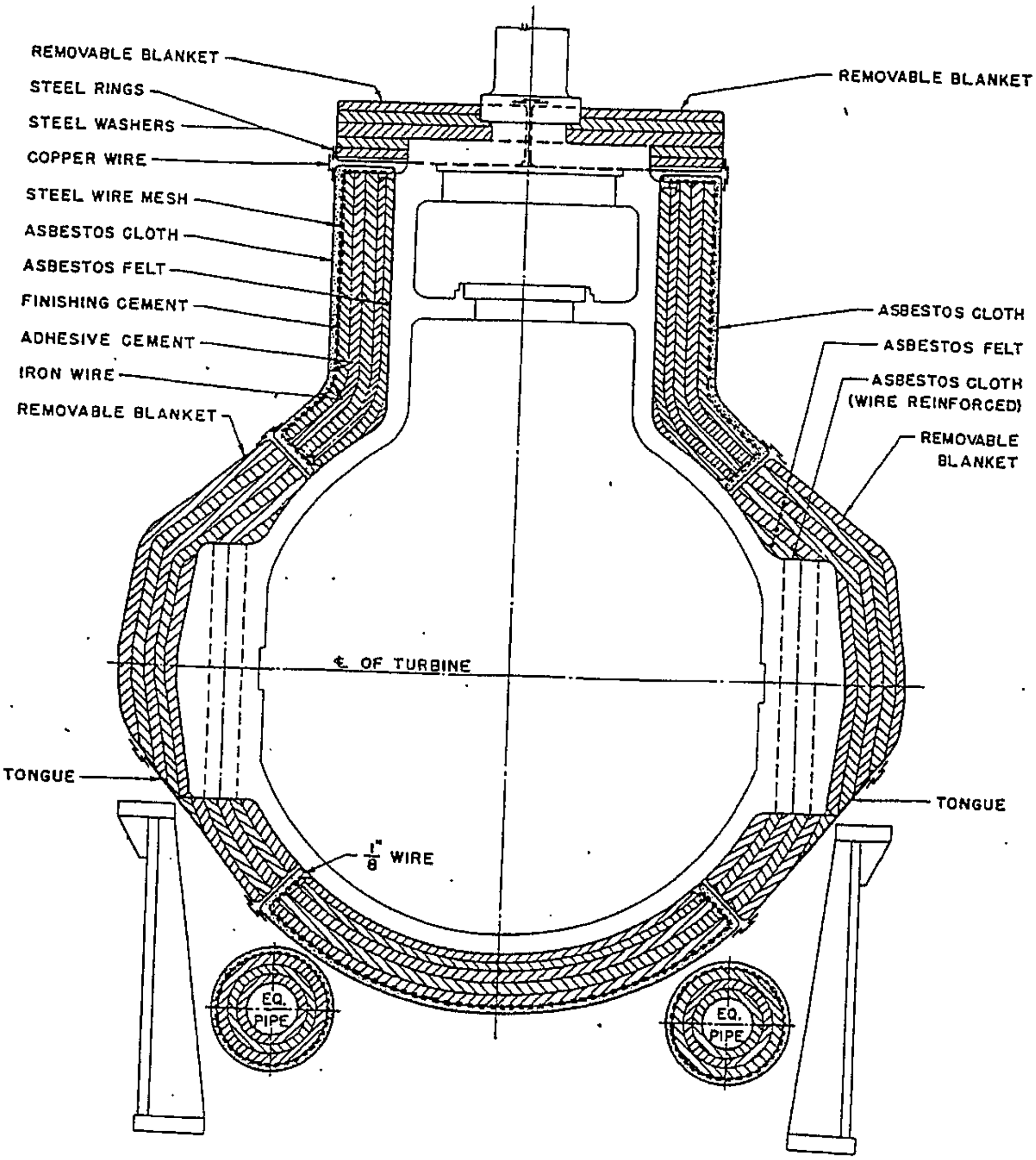

FIGURE 39–12

(4) Mineral-wool high-temperature insulating cement, as described in paragraph 39-11 (18), is sometimes used to form the complete permanent insulation. It is applied in layers less than 1 inch thick and is reinforced with wire mesh. Each layer must be permitted to dry thoroughly before applying more cement. Finishing cement and lagging are applied as indicated in paragraph (1) above. Removable insulation is the same as outlined in that paragraph.

39-73. BOILER STEAM DRUMS, WATER DRUMS, AND HEADERS

For insulation of boiler casings and refractory linings see chapter 51. See table VI for thicknesses of insulation.

(1) Drum shells may be covered with sufficient layers of asbestos felt per paragraph 39-11 (13) to make up the required thickness. The method described in paragraph 39-72 (1) should be followed. Figures 39-13 and 39-14 show a typical installation including the manhole cover of asbestos felt enclosed in a container made of 16-gage sheet metal per paragraph 39-12 (10). Sometimes metallic lagging of 20-gage, galvanized sheet steel is used in lieu of asbestos cloth, as shown in Figure 39-15. The sheet steel is fastened with ¼-inch machine screws to ¼- by 1-inch flat bars bent to a suitable radius and imbedded in the finishing coat of cement.

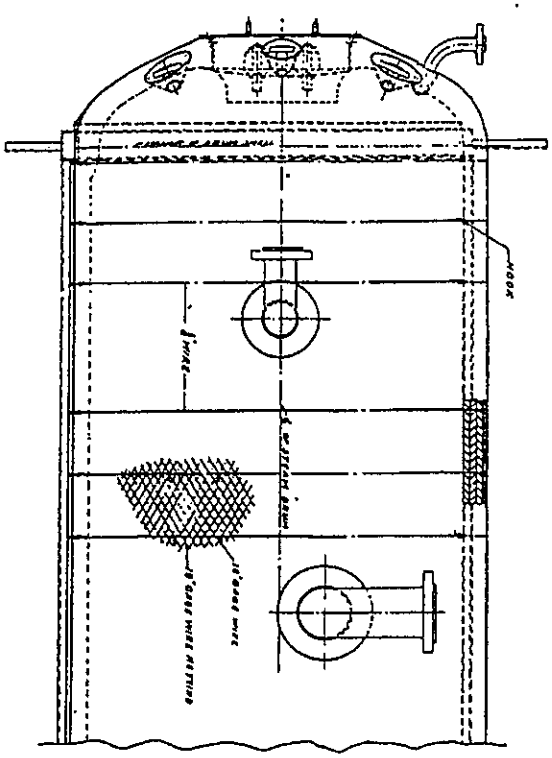

FIGURE 39-13

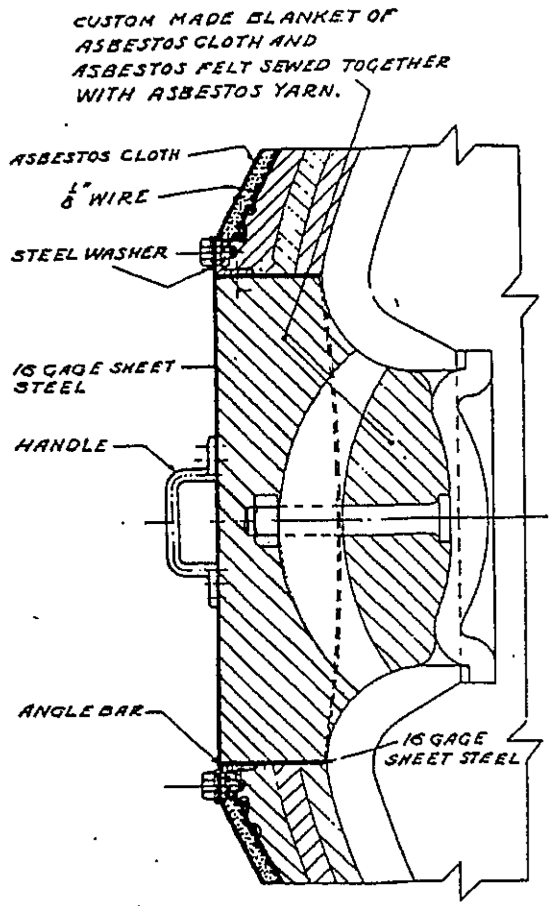

FIGURE 39-14

(2) Another method is to follow the procedure outlined in paragraph (1) above, but using mineral-wool-blanket insulating material per paragraph 39-11 (15) instead of asbestos felt. The type secured between 1-inch wire mesh and expanded lath should be used; the latter side should face outward. The drum ends may be insulated with high-temperature insulation cement of the rock or mineral-wool type described in paragraph 39-11 (18). Each layer of cement should be between ¾ and 1 inch thick and allowed to set for 24 hours or till dry. The manhole cover and the lagging should be of the type described in paragraph (1) above.

(3) Block insulation may be used for drum shells. Materials are described in paragraph 39-11 (9). Also large-size segmental pipe covering may be used. Application of this type of insulating material is outlined in paragraphs 39-71 (1) and 39-72 (3). The drum heads may be insulated with asbestos felt as described in paragraph (1) above or with cement as described in paragraph (2) above.

(4) Superheater headers may be insulated with custom-made blankets of asbestos felt enclosed in asbestos cloth. These blankets are laced to studs welded to the superheater support plate. Downcomer tubes and soot-blower piping should be insulated in accordance with part IV covering pipes and tubing.

39–74. UPTAKES

(1) Uptakes and breechings are constructed with an inner and outer casing between which the insulating material is placed. Glass fiber batts of 6-pound density described in paragraph 39–11 (14) may be used. It may be secured in place by wiring it to T bars which are suitably spaced and attached to the inner casing. Also it may be secured by impaling it on studs used to support the outer casing. Washers made of asbestos millboard per paragraph 39–12 (8) may be placed on the studs to hold the batts in place until the outer casing is installed.

(2) Mineral wool blanket insulation per paragraph 39–11 (15) also may be used for insulating uptakes. It should be wired in place with separate pieces butted closely together.

39–75. LOW PRESSURE DISTILLING PLANT

(1) The evaporator shells and the upper half of the evaporator ends, the vapor feed heaters, and air ejector condensers are permanently insulated with asbestos felt and cement with lagging in the manner described in paragraph 39–72 (1). The lower half of the evaporator ends should be covered with removable asbestos felt blankets of the type discussed in paragraph 39–72 (1). Refer to table VI for recommended thicknesses of insulation. The removable blankets may be fixed to 22-gage, galvanized sheet steel covers made in sections to suit the installation. Sections are held together and to the evaporators with ¼-inch machine screws or self-tapping screws. The blankets are secured to the metallic lagging by 18-gage, galvanized iron, or copper wire through rings attached to the blankets and hooks welded to the steel lagging.

(2) The condensate cooler should be covered as is required for cold water service. Use a 1-inch layer of asbestos felt and cement the same as on above apparatus. Over the cement apply one layer of water repellent and flameproof sheathing paper with vapor seals as instructed in paragraph 39–39 (1). Lag with asbestos or glass cloth.

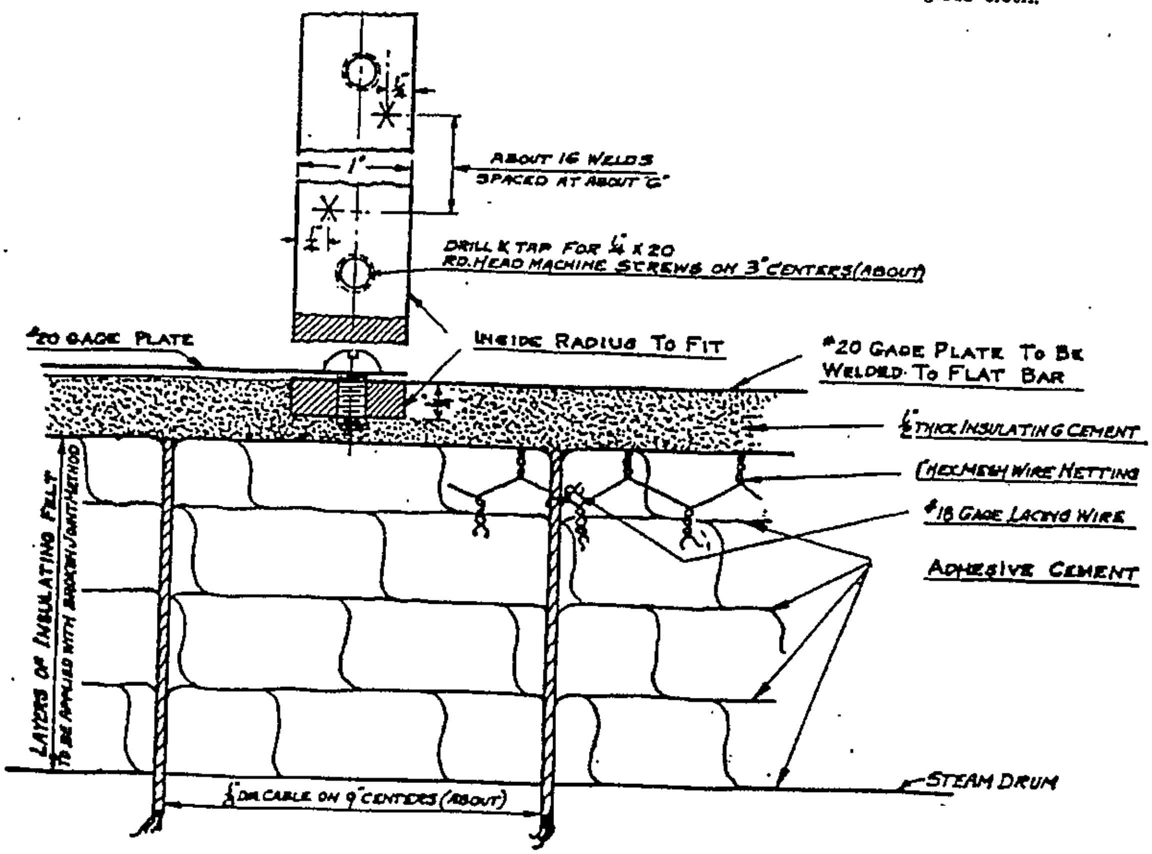

FIGURE 39–15

SECTION II—HULL INSULATION

Part 1.—Scope

39-101.

The thermal insulation discussed in this section differs from that in the first section, which covered the insulation of heat-producing equipment, by being concerned with the insulation of the structure of ships and their ventilating systems to improve habitability aboard ship. In the text which follows, the principles which guide the Bureau in establishing policies for the utilization of hull insulating materials are briefly reviewed and the consequent instructions are set forth as to the insulating materials to be used, where and how they are to be installed, and how repaired.

Part 2.—General

39-111. DEFINITION

Thermal hull insulation embodies the application of material, having high resistance to the flow of heat, to the surface of structure and other panels having relatively low resistance to the flow of heat. Thermal insulation differs from acoustical and electrical insulation, which are applied to retard the flow of sound and electricity, respectively. However, in some instances where acoustical insulation is installed, the application of additional thermal insulation is not necessary.

39-112. NEED FOR INSULATION

(1) Living and working compartments exposed to the weather are protected from the extremes of temperature due to the seasons, latitude, and time of day. Compartments adjacent to the propulsion and other machinery spaces and uptake enclosures are protected from the high temperatures prevalent in those spaces. Protection of spaces from their adverse surroundings is accomplished best by the complementary use of insulation and ventilation. The insulation retards the flow of heat into or out of the space, and ventilation removes excess heat or supplies heat to the space. Occasionally, it is possible to maintain the desired temperatures within a compartment by the use of either insulation or ventilation alone. In the interest of weight saving and reduction of construction and maintenance costs, this procedure is followed where it accomplishes the desired results. In most instances, however, both insulation and ventilation are utilized.

(2) The temperatures which ventilation and insulation are designed to maintain in Naval vessels, and a method of determining heat losses and quantities of ventilation and required thicknesses of insulation are included in the General Specifications for Building Vessels of the United States Navy, as modified by the detail specifications for a given ship.

(3) Different exposures and heat sources (chiefly personnel and equipment) affect the quantity of air to be circulated. Without thermal insulation, excessively large quantities of air for either heating or cooling would be necessary. Insulation on ducts of ventilation systems is often necessary to limit gain or loss of heat from the air in the ducts or to prevent condensation.

39-113. THICKNESS

(1) The rate of heat flow through a homogeneous insulation is in inverse proportion to the thickness. When installed, however, the insulation can no longer be considered as homogeneous since the structure to which it is secured and the air films on either side of the composite bulkhead-and-insulation or deck-and-insulation must be considered. Because of this, equal increments in the thickness of insulation do not yield equal reductions in rate of heat transfer. Practically, this consideration means that small variations of insulation thickness do not materially affect the rate of heat flow and, therefore, the corresponding air volumes required. As a result, it has been possible to adopt uniform thicknesses of insulation for varying rates of heat transfer at different temperature levels. The thicknesses in general use are:

(a) *One inch.*—For all spaces requiring insulation where exposed to water or the weather, for insulated boundaries of mechanically cooled spaces, and for surfaces on which insulation is used as a fire retardant medium.

(b) *Two or three inches.*—Where required adjacent to heat-producing spaces, such as propulsion and distilling machinery, trash burner rooms, and certain workshops.

(c) *Six inches.*—For refrigerated spaces.

(d) *Five-eighths of an inch.*—For ventilation ducts requiring insulation.

(2) Occasionally, other thicknesses are installed to meet special conditions. As an example, on destroyer-type vessels, where weight is a primary consideration, ¾-inch thick board is used in lieu of 1-inch board. If there is any doubt as to the thicknesses of insulation to be installed when replacing insulation, the insulation plans for the vessel should be consulted. For new designs the thicknesses of insulation are designated in the detail specifications for the particular vessel. In the absence of any specific instructions, the use of thicknesses given above is acceptable.

39-114. SWEATING

An outstanding instance wherein increased ventilation cannot always compensate for a deficiency in insulation is in the "sweating" of surfaces. Condensation of moisture occurs when the temperature of the surface is at, or below, the dew point of the contiguous air. In most instances the temperature on the warm side of a boundary of a cooled space

can only be elevated sufficiently to prevent condensation by providing adequate thickness of insulation. For this reason, additional insulation is generally installed on the underside, and occasionally on the warm side of bulkheads of refrigerated spaces. Under extreme continued high differentials between space dew point and metal surface temperature, the insulation so installed, regardless of thickness, may not be adequate to prevent condensation and corrosion of the metal surface.

Part 3.—Hull Thermal Insulation

39–121. APPLICATIONS

The insulation which is applied to the shell, bulkheads, deckheads, and the stiffeners and beams of these structural components of a vessel's hull is here termed "hull thermal insulation" to differentiate it from the thermal insulation applied to equipment, cold storage spaces, and the ducts of ventilation systems. The insulation is installed in the locations and thicknesses enumerated in Section L–2 of the General Specifications for Building Vessels of the United States Navy and in the detail specifications for the particular vessel. Where it is necessary to install hull insulation on the stiffener side of bulkheads, on the shell, on the underside of weather decks, or on overheads in machinery spaces, the exposed webs and flanges of the stiffeners (frames or beams) are in many instances also covered, or partially covered, with insulation.

39–122. MATERIALS

(1) Hull insulation used on naval surface vessels consists of fibrous glass board conforming to Bureau of Ships Spec. 32–G–8 (INT). The board is faced with a layer of treated and hardened fibrous glass cloth which provides a rigid, damage-resistant surface. Fibrous glass stripping tape, for covering and sealing the seams formed by the adjacent 24- by 36-inch panels of board, is included in the same specification. Both board and tape may be easily cut to fit any shape or contour of the structure. Fibrous glass board is attached to vessel's structure by use of cement conforming to Navy Department Spec. 52C23, and by use of threaded studs welded to the structure, over which the board is placed. The board is secured by washers and nuts. The purpose of the cement, which is provided in two types, A and B, is to secure the tape, to seal the seams of adjacent panels to prevent glass fibers from escaping and moisture from entering, and, when applied to the back of the board, to prevent the board from shifting in service. Type A cement is used on the back of the board. Type B cement is used to fill the seams and secure the tape over the seams. It may also be used on the back of the board when the air temperature is above 40° F. Below that temperature, type B cement will not perform as well as type A cement.

(2) A complete description of the welding attachments for securing the board in place rapidly and in a manner to resist all vibrations and other shocks which might dislodge it, if secured with cement alone, is given on Bureau of Ships Drawing 692SK2742 (fig. 39–21). Various studs for securing insulation to medium, high tensile, and special treatment steel and to armor plate are shown thereon, as are also drawings of the welding ferrule which must be used to insure satisfactory welds, and the special washer and nut which secure the insulation. Studs for welding to medium, high tensile, and special treatment steel no greater than ¾-inch thick are of low carbon steel (SAE 1010). They are designated as types A and B in figure 39–21. For welding to special treatment steel greater than ¾-inch thick and to class A and B armor, another low-carbon stud, designated as type C, is used.

39–123. INSTALLATION

(1) The first step in installing hull insulation is to inspect the steel to which it is to be applied for corrosion. It is important that the protective coating be intact to prevent subsequent corrosion of the metal by moisture which may penetrate through the board to the steel. Where necessary, the steel surface should be touched up with zinc chromate primer. Before any board is installed the surfaces should also be free of any grease or dirt. At the time the surfaces are inspected, measurements should be made of the stiffeners whose flanges and webs are to be insulated. Prefabrication of insulation into wrappings has been found to be the best method of covering stiffeners, since a minimum of cutting and fitting is thereby required, and sections of stiffeners are insulated in one operation. The method consists essentially of cutting V grooves, properly spaced, on the back of the insulation board, removing the loose strips of board where the intersecting cuts meet just below the cloth facing, and then bending to shape for fitting around the flanges. Descriptions of equipment which has produced good results were published in the July 1946 issue of Bureau of Ships Shop Notes.

(2) These are two acceptable methods for securing the board to the structure. In one, the studs are laid out and welded in place on the structure, with due regard to the number required and dimensions and contour of the section of board to be installed. The board is then daubed with cement on the back and coated heavily on all edges, and is then impaled over the studs. The other acceptable method differs in that each section of board is first fitted into place, and locations of the studs determined by punching through the board to mark the steel. The board is then removed, the studs welded, the board cemented as above, and then slipped over the studs through the holes previously formed. In both methods, after the board is in place and pressed

firmly against the structure, the washers and nuts are secured over the stud, as shown in figure 39–21, to hold the insulation permanently in place. In either of the two acceptable methods, sufficient studs must be used to hold the board firmly and evenly against the structure. In all instances, it is imperative that each welded stud be tested to insure that the weld is sound and will not fail in service. Each weld is to be tested by slipping the special tool shown in figure 39–21 over the stud as far as it will go, and bending once through an angle of 15° and return.

(3) In both methods of installation the seams may be filled with cement after the boards are installed in lieu of coating the edges forming the seams at the time the board is set in place. When this is to be done, a gap of not more than ⅛ inch should be left between each section of board as it is set in place, and the seams calked with the equipment shown on Bureau of Ships Drawing 631SK23 (fig. 39–22). Sealing seams in this manner is restricted to the use of type B cement and an ambient temperature of more than 40° F., since type A cement will not operate well in calking equipment.

(4) Until a stud for welding to aluminum structure is available, insulation should be secured to aluminum structure by impaling the board over split galvanized clips which have been riveted to the aluminum structure at their unsplit ends. A washer, similar to that shown on figure 39–21, is slipped over the free end of each clip after the board is in place, and the split ends of the clip are then bent in opposite directions flat against the washer.

(5) Types A and B studs are stud-welded by use of a special welding gun in which the stud acts as the electrode through which current is passed for a brief interval as the gun is held away from, and then pressed against, the structure. When the current is released and the gun drawn away, the stud is released from the gun and remains affixed, welded, at right angles to the structure. Type C stud is secured by manually arc-welding a fillet weld around the base of the stud.

(6) In those instances where stud welding is used, it is recommended that it be done with automatic welding equipment, by which the duration of the welding current and length of arc forming the weld are preset and mechanically controlled. In this manner, variations in the judgment and skill of welders are eliminated and the probability of securing uniformly sound welds is increased. It is acceptable to form the welds by the simpler type of stud welding gun, which requires manual control of the length of arc and duration of welding current. It is mandatory, however, that each weld be tested as described above regardless of the equipment used to form the weld.

(7) No sheathing is permitted over any fibrous glass board hull insulation. In the past, sheathing has been permitted because the face of the board was not very hard and was, therefore, susceptible to injury. Fibrous glass board conforming to Bureau of Ships Spec. 32G8 (INT) is tough and resistant to almost all forms of damage. It, therefore, does not require any sheathing. After the board is installed it should be painted to match the other surfaces in the compartment.

39–124. INSPECTION

Hull insulation should be inspected at least at semiannual intervals together with other portions of the hull structure. Action should be taken to have all damage, including that considered as minor, repaired at once since prompt repair will forestall development into major repair jobs.

39–125. REPAIR

(1) Two procedures for repair of damaged fibrous glass board insulation have been established; one for accomplishment by ship's forces, and the second by qualified repair activities. Each vessel fitted with fibrous glass board insulation has been allowed a repair kit consisting of 8 rolls of fibrous glass tape and 2 gallons of type B adhesive cement for shipboard repair of small tears, dents, gouges, and similar damage to the insulation. Application of the tape will, in most instances, prevent further damage and insure the continued serviceability of the insulation until the next overhaul of the vessel when, if warranted, more extensive repairs can be made.

(2) For extensive repairs to the insulation, a method is available whereby in most instances the insulation may, in lieu of being replaced, be repaired economically and with facility, with a resultant condition at least equal to that of newly installed board. The method has been developed especially for the repair of soft-faced fibrous glass board, Navy Department Spec. 32G6, which was the type used prior to the introduction of the hard-surfaced board, specification 32G8. It is, however, fully applicable to the latter insulation.

(3) The method, which consists essentially of cementing a cloth covering (stock numbers 32–C–1928 and 32–C–1928–36) over the insulation, is based on the fact that most damage occurs initially to the glass cloth surface, and leaves the body of the board relatively intact. One gallon of cement (stock number 52–C–728–260) is required for each 40 square feet of cloth.

(4) Before the covering is applied, the damaged insulation is to be prepared as follows:

(a) Protect all free edges of insulation terminating at doors, air ports, and similar openings with an angle bar welded to the structure.

(b) Fill with cement all exposed seams around attachments through the insulation.

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BUREAU OF SHIPS

MANUAL

CHAPTER 39

THERMAL INSULATION

NAVY DEPARTMENT,
Bureau of Ships,
1 April 1947.

This chapter is a revision of Bureau of Ships Manual, Chapter 39, "Thermal Insulation," dated 24 August 1945.

This revised chapter becomes effective upon receipt and shall be inserted in its proper place in the Manual binder.

E. W. MILLS,
Vice Admiral, U. S. N.,
Chief of Bureau.

Approved:
JAMES FORRESTAL,
Secretary of the Navy.

NAVSHIPS 250-000-39

Chapter 39

THERMAL INSULATION

CONTENTS

SECTION I—MACHINERY AND PIPING INSULATION

Part 1.—General

39-1. DEFINITIONS

(1) Insulating material is defined as the material employed to offer resistance to the flow of heat.

(2) Lagging is defined as the protective and confining covering or jacket placed over the actual insulating materials.

(3) Fastening is defined as the miscellaneous items with which insulating material is attached to the surface being covered and with which lagging is fixed to the insulating material.

(4) Insulation is defined as the composite covering including insulating material, lagging, and fastening.

39-2. REASONS FOR INSULATING

(1) In every power plant there is a heat loss from all heated surfaces and a heat flow to all cooled surfaces. Heat flow may occur in three ways; by conduction, by convection, and by radiation.

(2) Conduction is the heat flow from one part of a body to another part of the same body, or from one body to another with which it is in physical contact, without displacement of the particles of the body. This manner of heat flow is most important in insulation as it is the low conduction which results in the greatest temperature differential between a hot insulated surface and the atmosphere (as in steam piping insulation), or the relatively warm atmosphere and a cold surface (as in refrigerating plant insulation). Heat transfer from insulated pipes or large blanketed or cemented surfaces (turbines, evaporators, etc.) to the outer surface of their lagging is included in this mode. Conduction is associated with solids and comparison of materials in this respect is measured by a factor called the "thermal conductivity" which expresses rate of conductivity in British thermal units (B. t. u.) per inch of thickness per hour per square foot of area per degree Fahrenheit temperature differential.

(3) Convection is the transfer of heat from one point to another within a fluid, gas, or liquid, by circulating or mixing of one portion of the fluid with another. These currents are produced by warm fluid being displaced by heavier cold fluid. It is of interest to note that convection reduces the effectiveness of air space insulation unless such space is very small.

(4) Radiation is the method of heat transfer by which a hot body gives off energy in the form of radiant heat which is emitted in all directions. Radiant heat, like light, travels in straight lines and with the speed of light. The surface condition greatly affects the ability of a body to radiate heat. Dull, dark, rough finished surfaces are the best radiators. Conversely, bright, shiny, smooth surfaces are good heat reflectors.

(5) In order to minimize the transfer of heat from or to a body or surface which is hotter or colder, respectively, than the surrounding atmosphere, thermal insulation is applied. This thermal insulation

is a material or materials of low thermal conductivity. (See par. 39-2 (2).) While increasing the economy of the plant, thermal insulation also reduces the quantity of air necessary for ventilating and cooling requirements and prevents injury of personnel due to burns from contact with hot parts of apparatus. It also insures more uniform heat distribution within equipment. Another function of thermal insulation is to prevent "sweating" of cold surfaces on which atmospheric moisture condenses thus causing undesirable dripping as well as accelerated corrosion of the metal. Insulation must be sufficiently effective to reduce heat losses and lower surface temperatures to a degree which will permit habitable conditions in a specific space or compartment.

Part 2.—Materials

39-11. INSULATING MATERIALS

(1) The following requirements should be met as nearly as possible by thermal insulating materials:

(*a*) Low heat conductivity.

(*b*) Noncombustibility.

(*c*) Lightweight.

(*d*) Capability of easy molding and application.

(*e*) Moisture repellent.

(*f*) Noncorrosive, insoluble, and chemically inactive.

(*g*) Composition, structure, and characteristics ʼıanged by temperatures at which it is to be

(*h*) Once installed, should not cluster, become lumpy, disintegrate or build up in masses from vibration.

(*i*) Vermin proof.

(2) Insulating materials are available in the following forms in accordance with Navy Department Specifications:

(*a*) Molded sectional pipe covering:

Thermal insulation pipe covering	32P8
Molded cork (with fire resisting compound) pipe covering	32P11

(*b*) Block:

Thermal insulation block	32I3

(*c*) Batts, blankets and felts:

Roll asbestos felt	32F1
Asbestos insulating felt	32F3
Fibrous glass batt insulation	32I1
Mineral wool blanket insulation	32I2
Mineral wool pipe covering for low temperature	32I5
Thermal insulating tape	32T1

(*d*) Plastic:

High temperature insulation cement	32C14
Magnesia plaster	32P10

(3) Thermal insulation pipe covering, Spec. 32P8, grade I, usually is 85 percent magnesia and it is suitable for temperatures from 100° up to 500° F. Eighty-five percent magnesia is a molded product formed from a combination of 85 percent magnesium carbonate with about 15 percent asbestos fiber for strength and bond. It is made in standard and light density (classes a and b) which weigh 16 and 12 pounds per cubic foot, respectively. The standard weight material is used mostly; it is harder, stronger (in rupture) and less affected by heat than the light grade, but it is about 25 percent poorer in insulating value. The pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. Larger sizes are furnished in quadrant or segmental form. Sections which become broken may be reused as plastic cement by breaking up the material and mixing it with water.

(4) Thermal insulation pipe covering, Spec. 32P8, grade II, class c, is a fibrous product usually formed from a uniform mixture of asbestos fibers (composed mostly of pure silica and the oxides of iron and magnesium) and held together with a sodium silicate (water glass) binder. Its average density is 13.5 pounds per cubic foot. It is considerably harder than either of the magnesia materials in paragraph 39-11 (3) and comparable to the standard magnesia covering as a good insulator. It is resilient, tough, and withstands vibration. It has a smooth, brown, finished surface. Molded asbestos saws and cuts neatly with ordinary tools. It can be used for temperatures up to 750° F. and is manufactured in cylindrical sections 3 feet long, split in half lengthwise. Class d under grade II of Spec. 32P8 covers compounded materials. These are products which have been developed comparatively recently and which vary in composition. Grade II materials are suitable for temperatures up to 750°.

(5) Thermal insulation pipe covering, Spec. 32P8, grade III, class e, is a compounded material usually consisting of molded diatomaceous earth. It consists of practically pure silica blended and bonded with asbestos fibers. It is used in a single layer for insulating piping up to and including 1½ inches nominal size. For piping 2 inches and over in size, the insulation is in the form of combination pipe covering, the inner layer of which contacts the hot surface and is diatomaceous earth. The outer layer is 85 percent magnesia of the type described in paragraph 39-11 (3). This class of material is suitable for temperatures from 501° up to 900° F.

(6) Thermal insulation pipe covering, Spec. 32P8, grade III, class f, is a fibrous material usually consisting of asbestos similar to that described in paragraph 39-11 (4), but it is much harder and withstands high temperatures. It is used in a single layer for insulating piping up to and including 1½ inches nominal size. For piping 2 inches and over in size, the insulation is in the form of combination pipe covering, the inner layer of which contacts the hot surface and is high temperature material. The

outer layer is class c material. This pipe covering is available as combined sections with the two classes formed together to give the appearance and workability of a uniformly molded material. The average density is 17.5 pounds per cubic foot in the single layer and 16 pounds when used in the combination form. This material is suitable for temperatures from 751° to 900° F.

(7) The description herein of materials covered by Spec. 32P8 is based on materials as procured and their naval applications. All the common pipe covering materials have been discussed. As newly developed products are found to be suitable for naval use, such pipe coverings probably will be installed in addition to the common materials.

(8) Molded cork pipe covering, Spec. 32P11, is composed of cork joined by and coated over with a vapor-sealing compound. The pipe covering sections are made of pure granulated cork compressed into molds and held together by the natural cork gum as a binder. The fire retardant vapor-sealing compound is composed of chlorinated resins, drying oils, dryers, and fillers. A volatile solvent is added to attain the necessary fluidity for easy application with a stiff brush or trowel. At the time of installation the untreated molded cork insulating material is coated on all surfaces with the vapor seal. Each delivery of cork includes sufficient copper-clad steel wire and vapor seal for complete application. The molded cork is available in the following types: Ice water thickness, brine thickness, and special brine thickness. Pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. Cork covers for elbows, T's, valves, etc. are available. This material is of low thermal conductivity, high structural strength, almost free from shrinkage, resists moisture penetration when thoroughly coated, and acts as a good insulating material for refrigeration service.

(9) Thermal insulation block, Spec. 32I3, is furnished in 3 classes according to the allowable temperatures for which the materials are suitable. Class A of the specification covers insulating material for temperatures up to 500° F. These blocks usually are made of 85 percent magnesia or asbestos with characteristics as described in paragraphs 39-11 (3) and 39-11 (4), respectively. The maximum density for this class is 15 pounds per cubic foot. Block insulation is flat and rectangular. Asbestos block should be used where unusually high resistance to compression is required.

(10) For class B of Spec. 32I3, temperature range of 501° to 1,000° F., high temperature molded asbestos of the composition described in paragraph 39-11 (6) can be used. Diatomaceous earth high temperature insulating material in molded block form also is available for this service. It is described in paragraph 39-11 (5).

(11) For the higher range of temperatures, 1,001° to 1,500° F. covered by class C of Spec. 32I3, diatomaceous earth material in block form is used.

(12) Roll asbestos felt, Spec. 32F1, is composed of medium long asbestos fiber and organic sizing. The materials are felted into sheets, with an indented surface, of such flexibility that it may be folded, bent, or wrapped around piping and equipment. It is furnished in rolls ⅛ or ¼ inch thick and 3 feet wide. The ¼-inch roll weighs about 1.2 pounds per square foot. This material is suitable for temperatures up to 900° F.

(13) Asbestos insulating felt, Spec. 32F3, is furnished in type A, plain, and type B, water repellent for cold piping. Plain felt is composed of asbestos fibers and cotton and binding materials if required. Water-repellent felt is composed of asbestos fibers, cotton treated with a suitable repellent agent, and a cotton fabric encasement. Asbestos felt has a maximum density of 12 pounds per cubic foot. Plain asbestos felt is furnished in rolls 50 feet long by 60 inches wide and in thicknesses of ¾, 1, and 1½ inches. It has perhaps the widest range of uses of the insulating materials as it has flexibility for fitting around valves or other irregular surfaces and it is suitable for a temperature range from cold water to 900° F. Water-repellent asbestos felt is furnished in rolls 50 feet long and in widths from 3 to 60 inches; thicknesses are ¾ or 1 inch.

(14) Fibrous glass batt insulation, Spec. 32I1, is composed of glass fibers bonded together to form a semirigid batt. The fibrous glass is pure glass in fibrous form and is inorganic and fireproof and resistant to salt water and some chemical actions. It cannot mildew, decay, or provide sustenance to insects, rodents, or vermin. The batts are furnished in two grades, one weighing 6 pounds per cubic foot and the other 4.5 pounds. Standard dimensions are 48 inches long by 24 inches wide by 1 to 3 inches thick. When this material is used at elevated temperatures, the binding agent burns out at a point between 450° and 600° F. Hence, batts should be enclosed by sheet steel for support when subjected to temperatures between 450° and 900° F. The material is suitable for insulating boiler uptakes.

(15) Mineral wool blanket insulation, Spec. 32I2, consists of fibers from slag, glass, or limestone made by a process of melting, blowing, or drawing, and annealing. The blankets are felted and reinforced by wire netting or metallic lathing on both sides. The material is suitable for use at temperatures up to 900° F.

(16) Mineral-wool pipe covering for low temperatures, Spec. 32I5, is composed of mineral-wool fibers felted into strip form encased in fire-resistant fabric. The pipe covering is furnished in sections 3 feet long and made to such a width that when laterally folded around a given size of pipe, a reasonably tight uniform covering results.

39–11

(17) Thermal insulating tape, Spec. 32T1, is composed of a woven asbestos jacket enclosing either an asbestos fiber or fibrous glass felting or sliver. The jacket is woven from yarn of asbestos fiber; it may be either in one tubular piece or fabricated of asbestos cloth sewed into tubular form. The tape is supplied in two forms, one for spiral wrapping and the other for lateral wrapping. That for spiral wrapping is 2 to 2½ inches wide and ¼ to ⅜ inch thick. The tape for lateral wrapping is 5¼ inches wide and ⅜ inch thick. It is suitable for temperatures up to 750°.

(18) High temperature insulation cement, Spec. 32C14, is available in two types. Type A is the diatomaceous earth or exfoliated mica type and is composed of a dry mixture of suitable grades of such refractory material ground fine, asbestos fibers, and clay binders, thoroughly mixed to obtain uniform distribution of the ingredients. Type B is the rock or mineral-wool type which consists of a dry mixture of rock or mineral-wool fibers, asbestos fibers, and binders, thoroughly mixed to obtain uniform distribution of the ingredients. This latter type is most suitable for monolithic insulation. The composition of the cement is such that when properly wetted with fresh water, it can be applied with a trowel or by hand to hot and cold surfaces. One hundred pounds of dry cement will cover 50 square feet of surface to a thickness of 1 inch. After application it weighs a maximum of 30 pounds per cubic foot. The cement is reclaimable for reuse. The thermal conductivity of this material is higher than the nonplastic materials. All cements covered by Spec. 32C14 are suitable for use at temperatures from 100° to 1,000° F., and some may be used for 1,800° F. service. It is very important that all rock or mineral-wool type cements which may be used shall have corrosion-resisting properties conforming to the specification.

(19) Magnesia plaster, Spec. 32P10, is a mixture of not less than 85 percent long-fiber asbestos. The plaster is supplied dry and when properly tempered with water, it can be laid on with a trowel or by hand to form a light, incombustible, porous, heat-insulating covering. The material has the characteristics of 85 percent magnesia pipe covering described in paragraph 39–11 (3). Magnesia plaster will adhere to cold metal only with difficulty and it will not adhere to hot metal. One hundred pounds of the material covers about 67 square feet of surface to a thickness of 1 inch. The density after being molded and dried is not more than 16 pounds per cubic foot. Magnesia plaster may be used for temperatures from 100 to 500° F. Cements of the types described in paragraph 39–11 (18) are better for all purposes except for finishing insulation to a very smooth surface.

39–12. LAGGING MATERIALS

(1) The definition of lagging in paragraph 39–1 (2) describes the purpose of this item. It protects the relatively soft insulating material from mechanical abuse to which it is exposed aboard ship as a result of men climbing over piping and the necessary handling of equipment. It supports the insulating material which is subjected to continual vibration. The lagging provides a smooth finish to be painted.

(2) Materials in accordance with the following Navy Department Specifications are used as lagging:

(*a*) Cloth:
- Asbestos cloth, strands and tape 32C11
- Cotton duck pipe covering 24D3
- Fibrous glass cloth, tape and thread (for lagging insulation) 32G9

(*b*) Paper:
- Asbestos paper and tape reinforced with cotton mesh 32P9
- Flameproof and water-repellent sheathing paper 59P7

(*c*) Board:
- Asbestos millboard 32M1

(*d*) Plastic:
- Asbestos insulation finishing cement 32C16

(*e*) Metallic:
- Zinc coated (galvanized) sheet steel 47S29

(3) Asbestos cloth, strands, and tape, Spec. 32C11, are made of good quality asbestos yarn or combination of asbestos and glass yarn and contain no rubber or other filling materials except cotton fiber. The types of cloth and tape are classified by the maximum allowable cotton content. Type A cloth and type G tape are intended for use as the lagging material for insulation on pipe or tubing at all temperatures; it is not to be used on valves, fittings, and flanges if it will be in contact with heated metal. It may be used on valves, fittings, and flanges where the temperature of the insulated surface is 500° F. or less, and for temperatures over 500° F. on applications such as butt-welding end fittings where it is desirable to lag the fittings with the material used on the tubing. A blue stripe is woven into the finished edge of this material which may be asbestos or combination of asbestos and glass yarn. The remaining types do not contain glass yarn. Type B, 90 percent asbestos cloth, is furnished with a red stripe woven in and is intended for use as the outside lagging on removable and replaceable covers for flanges and fittings or other applications on valves, fittings, and flanges where the temperature of the insulated surface is more than 500° F. Ninety-five percent asbestos cloth is furnished with or without wire insertion. That with the wire, type C, is intended for use as the inside lagging on removable and replaceable covers for valves, flanges, and fittings at all temperatures. The wire adds to the strength and stiffness of the lagging. Type D, 95 percent asbestos cloth without the wire, is intended for the same conditions as type C when strength and stiffness is not necessary. This material is furnished

with a green stripe woven into the finished edge. An 80 percent asbestos sewing thread and a 95 percent yarn reinforced with wire are available under the specification.

(4) Fibrous glass cloth, tape, and thread, Spec. 32G9, are manufactured from a good quality of fibrous-glass yarn. The tapes and cloths are made in various weights and weaves, the most frequently used being described herein. Tight, satin-weave, lightweight cloth is recommended for straight pipe. For irregular surfaces, tight, broken-twill weave, heavyweight cloth should be used. Medium, plain weave, lightweight tape in 2- to 6-inch widths is suitable for curved pipe in particular. Tapes are applied with a minimum amount of labor and time. The sewing thread is a twisted specially treated cord. *Fibrous glass materials are not recommended for use where lagging is exposed to mechanical injury.* The material may be used for lagging surfaces with internal temperatures up to 900° F., but should not be used on removable and replaceable covers nor where it will be in contact with hot metal surfaces.

(5) Canvas or cotton duck, Spec. 24D3, has been widely used as a lagging material. Unlike asbestos and glass, duck is flammable and should be used only for service in the cold range of 36° to 99° F. Duck should not be used if glass cloth or asbestos cloth is available.

(6) Asbestos paper and tape reinforced with cotton mesh, Spec. 32P9, is composed of approximately 75 percent asbestos, 8 percent organic binder, and 17 percent cotton netting. This material is suitable for temperatures up to 500° F. It does not stand much abuse and is recommended for use only if glass or asbestos cloth is not available.

(7) Sheathing paper, Spec. 59P7, is made in three types. The flameproof and water-repellent paper does not support combustion and absorbs only the specified small weight of water. The two other types of paper have but one of the aforementioned characteristics. This material is used in conjunction with other lagging; see the instructions for insulation of cold water piping in part 4. The paper is supplied in rolls 36 inches wide.

(8) Asbestos millboard, Spec. 32M1, is composed of asbestos fiber and binding material formed under pressure into a sheet. It has a fair amount of insulating value for temperatures up to 400° F. but is mostly used as outside lagging on removable insulating covers to which it gives stiffness. It is available in thicknesses of from ⅛ to ½ inch in sheets the standard size of which is 42 by 48 inches. The maximum acceptable weight is 6.5 pounds per square foot of material 1 inch thick.

(9) Asbestos finishing cement, Spec. 32C16, is composed of asbestos fibers, fillers, and suitable binders thoroughly mixed to obtain a uniform distribution of the ingredients. The composition is such that when properly wetted with fresh water, it can be readily troweled to a smooth surface. One hundred pounds of cement has a covering capacity, applied and dried, of 19 square feet 1 inch thick. About 100 pounds of water is required to mix 100 pounds of cement. Asbestos cement is used as a surface finish over insulating material to seal all joints and provide a hard, smooth finish to which lagging is applied.

(10) Galvanized sheet steel, Spec. 47S29, is used as described in the sections on application of insulation.

39-13. ADHESIVE MATERIALS

(1) Adhesives which comprise one type of fastening as defined in paragraph 39-1 (4) are covered by the following Navy Department Specifications.

Fibrous adhesive insulation cement	52C22
Adhesive and sealing cements	52C23
Sodium silicate solution (33.5° Baumé)	51S29

(2) Fibrous adhesive, Spec. 52C22, is suitable for securing woven asbestos cloth to insulating material employed on piping or other applications. The cement is ready for use without heating or addition of other ingredients, except that it may be furnished in the unmixed form to be mixed just prior to use. It will not deteriorate for an indefinite length of time when enclosed in airtight metal containers. When used for fixing lagging or insulating materials to other than metal surfaces, 75 pounds of adhesive will cover about 100 square feet. Adhesive cement per Specification 52C22 must never be used for securing fibrous glass cloth or insulation since it causes disintegration of such materials. Therefore, this cement is not to be used with type A cloth or type G tape per Spec. 32C11.

(3) Adhesive insulation cement per type B of Navy Department Specification 52C23 is suitable for securing all lagging materials. It has the best properties of the adhesives described herein. Cements in accordance with the specification will not corrode steel when applied thereto.

(4) Sodium silicate solution, Spec. 51S29, may be used for fastening asbestos cloth. The cloth, when soaked in the silicate of soda and applied to the surface, molds into position and dries to form a hard, firm finish which resists abrasion. The remarks in paragraph 39-13 (2) in regard to the use of fibrous adhesive cement with fibrous glass materials apply also to sodium silicate solution.

Part 3.—Application of Thermal Insulation
General

39-21.

(1) Cloth and paper lagging should be covered with one coat of fire-retardant paint, per Bureau of Ships Spec. 52P22, after installation. The inside covers of removable blanket insulation need not be painted. Canvas lagging, if used, should be given

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e coat of canvas preservative per Spec. 52C26 of color to suit the adjacent bulkheads or decks.

(2) All steampiping, valves, and fittings located in positions exposed to the weather or to salt water spray should be insulated and lagged watertight with sheet metal. Where it is not feasible to apply insulation, paint the piping with heat- and weather-resistant paint, and install suitable guards to protect personnel. Also use metal lagging where necessary to shield the insulation from damage. Metallic lagging, galvanized sheet steel, may be painted for appearance with one coat of zinc chromate primer, formula 84, followed by one coat of fire-retardant paint per Bureau of Ships Spec. 52P22.

(3) Where the detailed instructions which follow hereafter do not specifically cover any surface requiring insulation, such surface should be insulated in a manner similar to the requirements covering a condition which most nearly approximates that of the surface in question.

(4) At least once a year and preferably at 6-month intervals, a careful inspection should be made of insulation. All broken or loose insulating or lagging materials should be securely fastened in accordance with instructions herein. If much material is broken, a complete reinstallation is recommended.

(5) In the course of emergency repairs as a result of damage, insulation is to be stripped from piping in flooded compartments if practicable. This procedure will prevent serious corrosion of piping by insulation which carries a large amount of water even subsequent to unwatering operations.

(6) The following tables indicate various approved insulating, lagging, and fastening materials to be used and minimum thicknesses required for all services and temperature ranges.

TABLE I

Service	Temperature conditions (°F.)	Pipe or tubing		Valves and fittings	
		Insulating materials	Lagging	Insulating materials	Lagging
Superheated steam and exhaust gases.	751 to 900	32P8, grade III; 32T1	32C11, type A and G; 32G9.	32C14, type B; 32F3, type A; 32I3, class b; 32P8, grade III.	32C11, type A, B, C, D, and G; 32G9.
Do	501 to 750	32P8, grade II and III; 32T1.	32C11, type A and G; 32G9.	32C14, type B; 32F3, type A; 32I3, class b; 32P8, grade II and III.	32C11, type A, B, C, D, and G; 32G9.
Saturated steam, exhaust gases, hot water, and hot fuel oil.	100 to 500	32P8, grade I and II; 32T1.	32C11, type A and G; 32G9; 47S29.	32C14, type B; 32F3, type A; 32I3, class a; 32P8, grade I and II.	32C11, type A, B, C, and G; 32G9.
Cold water	32 to 99	32F3, type A and B; 32I5.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; 32I5	32C11, type A and G; 32G9; 59P7.
Refrigerant	36 and over	32F3, type A and B; 32I5; 32P11, type A.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; 32I5; 32P11, type A.	32C11, Type A and G; 32G9; 59P7.
Do	0 to 35	32P11, type B	32C11, type A and G; 32G9.	32P11, type B	32C11, type A and G; 32G9.
Do	Below 0	32P11, type C	32C11, type A and G; 32G9.	32P11, type C	32C11, type A and G; 32G9.

Service	Temperature conditions (°F.)	Flange joints		Machinery	
		Insulating materials	Lagging	Insulating materials	Lagging
Superheated steam and exhaust gases.	751 to 900	32F3, type A; 32I3, class b; 32P8, grade III.	32C11, type C and D	32C14, type B; 32F3, type A; 32I2; 32I3, class b.	32C11, type A, B, C, D, and G; 32G9.
Do	501 to 750	32F3, type A; 32I3, class b; 32P8, grade II and III.	32C11, type C and D	32C14, type B; 32F3, type A; 32I2; 32I3, class b.	32C11, type A, B, C, D, and G; 32G9.
Saturated steam, exhaust gases, hot water, and hot fuel oil.	100 to 500	32C14, type B; 32F3, type A; 32I3, class a; 32P8, grade I and II.	32C11, type A, B, C, and G; 32G9.	32C14, type B; 32F3, type A; 32I2; 32I3, class a.	32C11, type A, B, C, and G; 32G9.
Cold water	32 to 99	32F3, type A and B; 32I5.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B	32C11, type A and G; 32G9; 59P7.
Refrigerant	36 and over	32F3, type A and B; 32I5; 32P11, type A.	32C11, type A and G; 32G9; 59P7.	32F3, type A and B; HH-C-561.	32C11, type A and G; 32G9; 59P7.
Do	0 to 35	32P11, type B	32C11, type A and G; 32G9.	HH-C-561	32C11, type A and G; 32G9.
Do	Below 0	32P11, type C	32C11, type A and G; 32G9.	HH-C-561	32C11, type A and G; 32G9.

TABLE II.—*Compounded insulating material thicknesses for hot pipe or tubing*

Pipe size (inches)	Temperature range (°F.)	Class of material per Spec. 32P8: Inner layer	Class of material per Spec. 32P8: Outer layer	Thickness (inches): Inner layer	Thickness (inches): Outer layer	Thickness (inches): Total
				¾		¾
½ and ¾	100–388	a, b, or d		1¼		1¼
	389–500	a or		1¼		1¼
	389–500	b or d		1¼		1¼
	501–750	d or		1 13/16		1 13/16
	501–750	e		1 13/16		1 13/16
	751–900	e		¾		¾
1	100–388	a or		1 5/16		1 5/16
	100–388	b or d		1¼		1¼
	389–500	a or		1½		1½
	389–500	b or d		1½		1½
	501–750	d or		1 13/16		1 13/16
	501–750	e		1 13/16		1 13/16
	751–900	e				
1¼	Same materials and thicknesses as ½-inch size.			¾		¾
1½	100–388	a or		1 5/16		1 5/16
	100–388	b or d		1¼		1¼
	389–500	a or		1¾		1¾
	389–500	b or d		1¾		1¾
	501–750	d or		1 13/16		1 13/16
	501–750	e		1 13/16		1 13/16
	751–900	e		1½		1½
2 and 2½	100–338	a, b, or d		2		2
	339–388	a or		1¾		1¾
	339–388	b or d		3		3
	389–500	a, b, or d		3		3
	501–750	d or	a or b	1½	1 13/16	3 5/16
	501–750	e	a or b	1½	1 13/16	3 5/16
	751–900	e		1½		1½
3	100–338	a, b, or d		2		2
	339–388	a or		1¾		1¾
	339–388	b or d		3		3
	389–500	a, b, or d		3		3
	501–750	d or	a or b	1½	2	3½
	501–750	e	a or b	1½	2	3½
	751–900	e		1½		1½
3½	100–338	a or		1¼		1¼
	100–338	b or d		2		2
	339–388	a, b or d		3		3
	389–500	a, b or d		3		3
	501–750	d or	a or b	1¼	1 13/16	3 1/16
	501–750	e	a or b	1¼	1 13/16	3 1/16
	751–900	e		1½		1½
4	100–338	a, b or d		2 3/16		2 3/16
	339–388	a or		1¾		1¾
	339–388	b or d		3		3
	389–500	a, b, or d		3		3
	501–750	d or	a or b	1½	2	3½
	501–750	e	a or b	1½	2	3½
	751–900	e		1½		1½
4½	100–338	a or		1¼		1¼
	100–338	b or d		2 5/16		2 5/16
	339–388	a or		2		2
	339–388	b or d		3		3
	389–500	a, b or d		3		3
	501–750	d or	a or b	1¼	1 13/16	3 1/16
	501.750	e	a or b	1¼	1 13/16	3 1/16
	751–900	e				
5	Same materials and thickness as 4-inch size.					
6	Do.			1½		1½
7	100–338	a, b or d		2½		2½
	339–388	a or		2½		2½
	339–389	b or d		3		3
	389–500	a, b or d		4		4
	501–750	d or	a or b	1½	2	3½
	501–750	e	a or b	1½	2	3½
	751–900	e		1½		1½
8, 9, and 10	100–338	a, b, or d		2½		2½
	339–388	a or		2½		2½
	339–388	b or d		3		3
	389–500	a, b, or d		4		4
	501–750	d or	a or b	2	2	4
	501–750	e	a or b	2	2	4
	751–900	e		1½		1½
11	100–338	a, b, or d		3		3
	339–500	a, b, or d		4		4
	501–750	d or	a or b	2	2	4
	501–750	e	a or b	2	2	4
	751–900	e		1½		1½
12 and over	100–338	a, b, or d		3		3
	339–500	a, b, or d		4		4
	501–750	d or	a or b	2	2	4
	501–750	e	a or b	2	2	4
	751–900	e				

NOTE.—Temperature of saturated steam at 25 p. s. i. gage is 267° F.
Temperature of saturated steam at 100 p. s. i. gage is 338° F.
Temperature of saturated steam at 200 p. s. i. gage is 388° F.

TABLE III.—*Fibrous insulating material thicknesses for hot pipe or tubing*

Pipe size (inches)	Temperature range (° F.)	Class of material per, Spec. 32P8: Inner layer	Class of material per, Spec. 32P8: Outer layer	Thickness (inches): Inner layer	Thickness (inches): Outer layer	Thickness (inches): Total
				¾		¾
½ through 1½	100–388	c		1½		1½
	389–500	c		2		2
	501–750	c		2		2
	751–900	f		1½		1½
2 through 3½	100–338	c		2		2
	339–388	c		2½		2½
	389–500	c		3		3
	501–750	c		1¼	2	3¼
	751–850	f	c	1¾	1½	3¼
	851–900	f	c	1½		1½
4 through 6	100–338	c		2		2
	339–388	c		2½		2½
	389–500	c		3		3
	501–750	c		1½	2	3½
	751–850	f	c	2	1½	3½
	851–900	f	c	1½		1½
7 through 11	100–338	c		2 5/16		2 5/16
	339–388	c		2½		2½
	389–500	c		4		4
	501–750	c		1½	2½	4
	751–850	f	c	2	2	4
	851–900	f	c	1½		1½
12 and over	100–338	c		2¼		2¼
	339–388	c		2¼		2¼
	389–500	c		4		4
	501–750	c		1½	2½	4
	751–850	f	c	2	2	4
	851–900	f	c			

TABLE IV.—*Thicknesses of insulating materials in inches for cold water and refrigerant pipe and tubing flanges, valves and fittings*

Pipe size (inches)	Service	Temperature range (° F.)	Molded cork, Specification 32P11	Asbestos felt, Specification 32F3; types A or B	Mineral wool, Specification 32I5
Up to ¾	Refrigerant	Below 0	2.60		
	do	0 to 35	1.70	1½	1¼
	do	36 and over	1.20	1	1¼
	Cold water	All			
1 and 1¼	Refrigerant	Below 0	2.75		
	do	0 to 35	2.00	1½	1½
	do	36 and over	1.30	1	1½
	Cold water	All			
1½ to 5½	Refrigerant	Below 0	2.95		
	do	0 to 35	2.40	2¼	3
	do	36 and over	1.35	1	1½
	Cold water	All			
6 and 7	Refrigerant	Below 0	4.00		
	do	0 to 35	2.40	2¼	3
	do	36 and over	1.35	1	1¼
	Cold water	All			
8 to 12	Refrigerant	Below 0	4.00		
	do	0 to 35	3.00	2¼	3
	do	36 and over	1.35	1	1½
	Cold water	All			
Over 12	Refrigerant	Below 0	4.00		
	do	0 to 35	3.00	2¼	3
	do	36 and over	1.50	1	1¼
	Cold water	All			

TABLE V.—*Thicknesses of insulating tape per Spec. 32T1 for hot piping ¼- and ⅜-inch size*

Temperature range (° F.)	Thickness of tape (inches)	Number of layers	Total thickness (effective)
100–338	¼	1	[illegible]
339–388	1	1	[illegible]
389–500	1¼	1	[illegible]
501–750	¼	2	1
751–900	1 and ¼	1 of each	1

TABLE VI.—*Thicknesses of insulating materials for hot surfaces of machinery*

Temperature range (° F.)	Asbestos felt, block, or mineral wool blanket	Cement (Spec. 32C14, type B)
100–338	1½	1¼
339–398	2½	2¼
399–500	3	3
501–750	3½	4
751–900	4½	5

Part 4.—Application of Thermal Insulation to Pipe or Tubing

39–31. TEMPERATURES FROM 501° TO 900° F.

(1) Piping systems with temperatures over 500° F. include superheated steam piping and Diesel exhaust piping. Thermal insulation pipe covering, per Spec. 32P8, classes e or f, is used for services from 501° to 900° F. and is described in paragraphs 39–11 (5) and 39–11 (6). The thickness of pipe covering should be as shown in table II, which covers compounded insulating material or table III, which covers fibrous insulating material.

Single layer molded pipe covering is applied directly on the piping. Side and end joints should be tightly butted. Sections are securely fastened in place with 18-gage (0.049 inch diameter) nickel-copper, brass, or galvanized soft iron wire or metal bands. Use three loops or bands per length of insulating material on pipes up to and including 6 inches and four loops or bands on larger pipes. The ends of the wire loops are fastened together to hold the insulating material tightly against the pipe. The wire ends are bent over and carefully pressed into the pipe covering to leave no projection. Joints, cracks, or indentations in the surface of the insulating material are pointed up with high temperature insulating cement (Spec. 32C14) or asbestos finishing cement (Spec. 32C16). In double layer work both the longitudinal and circumferential joints of the second layer are staggered in relation to the first layer and both layers are secured as previously described. The outer layer may be pointed up with magnesia plaster if the insulating material is 85 percent magnesia.

Thermal insulating tape as described in paragraph 39–11 (17) is specially suitable for small piping and where space conditions render awkward the use of molded covering. The tape also is suitable for bends. Tape for spiral wrapping should be wired at each 10 inches approximately. Tape for wrapping laterally must be wired at each end of every strip. Thicknesses are shown in table V. The lagging should be type A or G asbestos cloth or tape or glass cloth or tape.

(2) *Bends.*—Where bends are encountered in the piping, the sectional insulating material is cut or mitered as shown in Figures 39–1, 39–2, and 39–3 to fit neatly around the contour of the bend. Care must be taken to insure that each segment is securely fastened in place. All openings and crevices are filled with high temperature cement, Spec. 32C14, or asbestos finishing cement (Spec. 32C16), troweled smoothly to a uniform surface. Sharp bends may be insulated with asbestos insulating felt per paragraph 39–11 (13) overlaid with ½ inch of high temperature insulating cement or asbestos finishing cement (Spec. 32C16) finished off smoothly.

39–32.

(1) *Application of glass cloth and tape.*—Glass cloth per paragraph 39–12 (4) is fitted on tight and smooth and sewed with fibrous glass sewing thread using a single stitch, three to the inch. Glass cloth and tape may be cemented on with adhesive cement per paragraph 39–13 (3). In general, tape rather than cloth is used for lagging pipe bends. Fibrous glass tape is applied in a spiral wrapping around the pipe. At the start the tape may be stapled to the insulating material or secured with an adhesive. On straight runs, a ¼-inch lap is sufficient. The tape may be furnished with a stripe woven in as a guide for lapping. On bends, the lap should be made at right angles to the axis of the pipe. A new roll of tape is started as if it were to be wrapped in the reverse direction and attached with staples or adhesive. The tape then is brought back over the fastening which thus is concealed from view. Where pipes are located close together, the tape may be applied easily by wrapping it on a smooth rounded edge metal "shuttle." The tape is fastened to the insulating material and the shuttle passed between the pipes, picked up on the far side, and the tape pulled tight.

(2) *Application of asbestos cloth.*—Asbestos cloth is fitted on tight and smooth. It may be sewed with asbestos yarn or may be cemented on. Adhesive cement per paragraph 39–13 (2) can be used to fasten asbestos cloth other than type A. Cements described in paragraph 39–13 (3) are suitable for all materials. The surfaces to be joined must be dry and clean. Apply the adhesive to the cloth, not to the insulating material. The more rough and porous the surface may be, the more adhesive will be needed. Asbestos cloth, except for type A, also may be fastened on with sodium silicate solution described in paragraph 39–13 (4). The cloth should be soaked in the solution and the insulating material given a liberal painted coat of the same. The lagging is applied while the surface is still wet.

39–33. DIESEL ENGINE EXHAUST FLEXIBLE CONNECTIONS

The connections may be insulated by one of the following methods:

(a) In accordance with paragraphs 39–31 (1) and 39–31 (2) provided the flexible connection is cov-

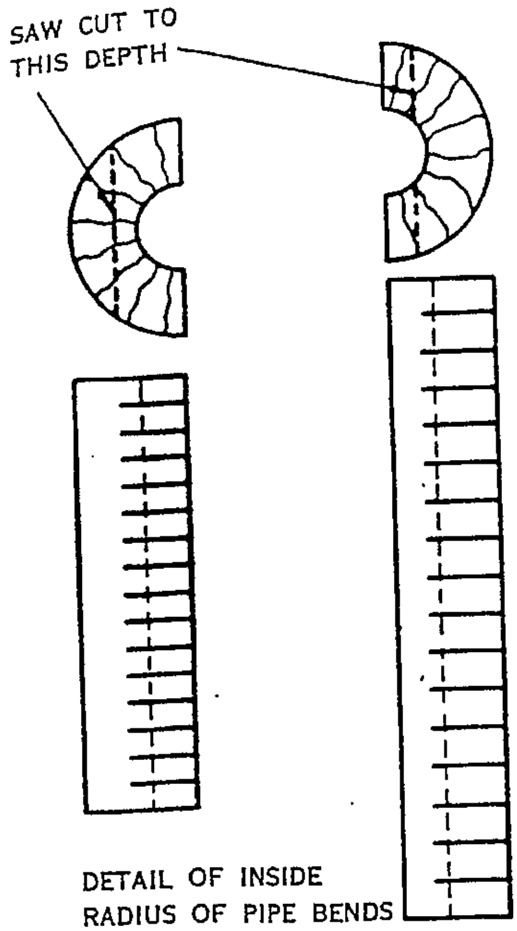

Figure 39-1.—Detail of outside radius of pipe bends.

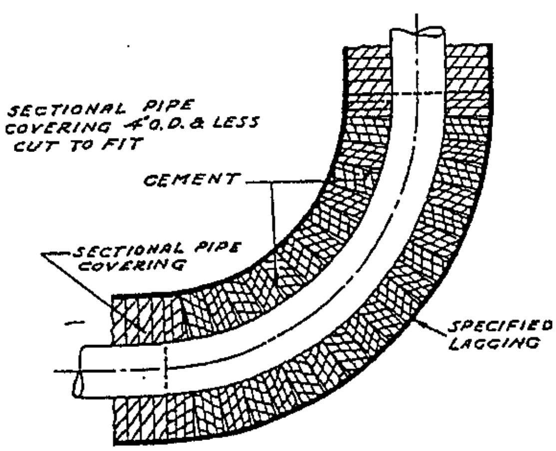

Figure 39-2.

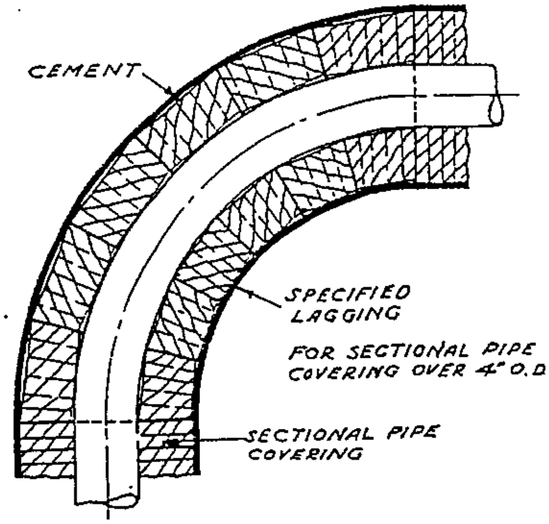

Figure 39-3.

ered with 1-inch galvanized wire mesh before application of the insulating material.

(b) Apply asbestos insulating felt per paragraph 39-11 (13) overlaid with a layer of asbestos paper which is described in paragraph 39-12 (6). Lag in accordance with paragraph 39-31 (1).

39-34. BULKHEAD EXPANSION JOINTS

Continue the insulation under the connection with the pipe covering butting each side of the flange which secures the joint to the piping.

39-35. PIPE HANGERS

Where pipe hangers are clamped around the piping, the sectional pipe covering may be stopped at the clamp and the space filled with layers of asbestos felt per paragraph 39-11 (13) to the thickness of the covering. A single layer of asbestos cloth which extends over the sectional covering 2 inches on either side is wrapped circumferentially over the felt and is secured by wire through rings and hook fasteners to form a take-down seam. A similar covering may be used on flanges to which are welded anchor lugs for pipe hangers. Hangers may also be insulated by fitting the molded pipe covering as necessary; use insulating cement to complete the installation.

39-36. TEMPERATURES FROM 100° TO 750° F.

(1) For temperatures between 100° and 750° F., thermal insulation pipe covering, Spec. 32P8, classes c or d may be used. The thickness of pipe covering should be as shown in table II or III. This material is applied in the manner described in article 39-31. Lagging may be in accordance with paragraphs 39-32 (1) or 39-32 (2).

39–37. TEMPERATURES FROM 100° TO 500° F.

(1) For temperatures between 100° and 500° F., thermal insulation pipe covering, Spec. 32P8, classes a and b, described in paragraph 39–11 (3) is used. Also see article 39–36. Lagging may be in accordance with paragraphs 39–32 (1) or 39–32 (2). If asbestos or glass cloth is not available, asbestos paper, which is described in paragraph 39–12 (6), may be used. The thickness of the pipe covering should be as shown in table II.

39–38. APPLICATION OF REINFORCED ASBESTOS PAPER OR TAPE

Asbestos paper or tape per Spec. 32P9 is generally used in the 36-inch sheet form on straight runs of piping although spiral wrapping with narrower widths of tape will give a satisfactory job. Use tape for fittings and bends. Asbestos tape should always be applied with the guide line on the outside. Do not apply asbestos paper or tape over wet cement. Apply cold water paste with a brush or sponge to pipe insulation before wrapping with asbestos paper or tape. If preferred, the paste or adhesive cement can be applied directly to the sheet material.

(1) *Paper:* Paste and/or staple the inner edge to the top of the insulating material and carry the paper around the pipe and paste on the outside edge lapping over a minimum of 2 inches. Paper can either be terminated at fittings, with tape applied thereto, or continued around fittings, mitering the inside lap, and molding in place by hand to give a continuous uniform appearance. Asbestos paper can be sewed in a manner similar to asbestos cloth when it is used on straight runs of pipe. After sewing, smooth down the edge with a sponge and water or cold water paste.

(2) *Tape:* Use the material dry. Start the application by fastening the tape to the insulation with a staple or paste. The guide line must be on the outside. Apply one wrap double thick to start and cover the staple, if used; then spiral the tape on overlapping each layer a minimum of ½ inch as indicated by the guide line. After spiral wrapping, smooth out irregularities in laps by applying water with a sponge to all spiral joints. Apply water at joints to change direction of wrapping when necessary to give a smooth appearance.

39–39. COLD WATER AT ALL TEMPERATURES

Three insulating materials may be used on cold water pipe or tubing.

(1) Asbestos insulating felt should be applied to thoroughly cleaned and dried pipe surfaces in the thicknesses shown in table IV. The material is described in paragraph 39–11 (13).

The felt is applied in ¾-inch layers which are compressed to ½-inch thickness by 18-gage nickel-copper, brass, or galvanized soft iron wire wound on about 1 inch centers. Joints in adjacent layers of felt are staggered longitudinally and radially. Water-repellent asbestos felt in strip form is applied longitudinally; the width is such as to enclose the circumference of the pipe. The following table gives pipe sizes and widths of felt which have been extensively used for these sizes:

Width (inches):	Pipe sizes (inches)
5	½ and ¾
7	1 and 1¼
9	1½ and 2
13	2½ and 3
16	3½ and 4
21	4½, 5, and 5½

The asbestos felt is covered with one layer of water-repellent and flameproof sheathing paper which is described in paragraph 39–12 (7). The paper should be tightly wrapped and lapped 3 inches each way. On bent piping the sheathing paper is mitered and fitted tightly. Joints must be sealed completely with adhesive cement (N. D. Spec. 52C23, type B). The lagging may be asbestos cloth per paragraph 39–32 (2) or glass cloth per paragraph 39–32 (1). Cotton duck described in paragraph 39–12 (5) may be used if the former materials are not available. The lagging should be cemented on with material per paragraph 39–13 (3).

(2) Mineral-wool pipe covering described in paragraph 39–11 (16) is suitable for low temperatures. The material is furnished in 1½-inch thickness only. It is applied similarly to the manner described in paragraph 39–39 (1).

(3) Molded-asbestos pipe covering (Spec. 32P8, class C), which is described in paragraph 39–11 (4), may be used for cold water lines if felt is not available. Apply sheathing paper and lagging in accordance with paragraph 39–39 (1).

39–40. REFRIGERANT

(1) Molded cork pipe covering described in paragraph 39–11 (8) is used in the thicknesses shown in table IV. See article 39–39 for other materials suitable for refrigerant at temperatures of 36° F. and over.

(2) At the time of installation, the fire-retardant vapor seal may be applied to the cork in the following manner: The inner surfaces of the semicylindrical sections of cork are heavily coated with the compound by brushing and allowed to dry at room temperature for 24 hours. The longitudinal surfaces and ends of each section of the covering are then coated with the compound and the sections are immediately installed, butted together longitudinally, and secured. In the installation of the sections, excess compound which is forced out of the longitudinal joints may be doctored off. The external surface of the covering is then given a brush coat of the compound which is allowed to dry for 48 hours.

(3) Pipes must be free from rust and moisture before applying insulation. Sectional covering should be applied with end joints broken by starting with one half- and one full-length piece. Longitudinal joints should be at the top and bottom of the pipe. Wire the sections in place with at least six copper-clad wires per 36-inch section. When the pipe passes through an insulated wall into a refrigerated room, the pipe covering should extend into the room 1 inch beyond the wall. Pipe bends are insulated by mitering regular sectional covering to fit the bend, using pieces small enough to give approximately full contact between the pipe and the covering. Pipe hangers must be on the outside of the covering and not in contact with the pipe. Frost will collect around the supporting rod of a hanger attached directly to the pipe and will eventually work under and split off the covering at that point. A 12- to 18-gage galvanized sheet-steel shield should be used between the hanger and covering where the pipe rests in the hanger. The shield should extend at least 3 inches on each side of the hanger. Glass or asbestos cloth or tape lagging should be applied in accordance with paragraphs 39-32 (1) or 39-32 (2), respectively.

Part 5.—Application of Thermal Insulation to Valves, Fittings, and Flanges

39-51.

Permanently insulated valves and fittings should be covered to the same total thickness as the adjacent piping. Valves and fittings which are welded into the line are insulated permanently. Flanged valves and flanged fittings may have permanent or removable type insulation. Where the pipe covering is terminated at flanges, provision must be made for removal of the flange bolts or bolt-studs. The pipe insulation may be stopped off squarely and a short removable section of insulating material of sufficient length to permit the withdrawal of the bolting may be inserted. A less desirable method is to omit the short removable section of insulation by terminating and beveling off the pipe covering at the necessary distance from the flange.

39-52. COVERS

Readily removable and replaceable covers should be provided on the following piping elements requiring insulation:

(1) Flanged joints (except valve bonnet joints) on all sizes of main and auxiliary steam piping carrying steam having a total temperature of 389° F. (205 p. s. i. saturated steam) and over, including flanged joints on all root connections and root valves thereon, such as valve bypasses, drain connections, pressure gage connections, etc.

(2) Flanged joints on piping and adjacent to machinery units which must be broken when these machinery units are opened for inspection and overhaul, such as steam exhaust connections, feed pump suction and discharge connections, steam drain connections, etc.

(3) Valve bonnets on all valves over 2 inches in size, working pressure of 300 p. s. i. and over, carrying fluids 240° F. and over.

(4) Pressure reducing and pressure regulating valves, pump pressure governors, and strainer bonnets.

39-53. METHODS OF MAKING COVERS

Readily removable and replaceable covers for piping elements are made by the following methods:

(1) Rigid covers made in two halves filled with asbestos felt are shown in figures 39-4 and 39-5. Covers are sewn and quilted with wire inserted asbestos yarn (Navy Department Spec. 32G11, type E) in such a manner as to provide a uniform thickness. Wire inserted asbestos cloth (Navy Department Spec. 32C11, type C) is used on the inside of the covers to provide strength and rigidity. Asbestos cloth (Navy Department Spec. 32C11, type B) is used on the outside surface of the cover if the temperature of the insulated surface does not exceed 500° F. For temperatures over 500° F. asbestos cloth (Navy Department Spec. 32C11, type D) is used on the outside of the cover. Flexible asbestos millboard, ⅛ inch thick, is inserted between the asbestos felt and the asbestos cloth so as to retain the cylindrical shape of the cover. Hard asbestos millboard, ¼ inch thick, enclosed in asbestos cloth of the type used on the outside of the cover is sewn on the ends of the cover. Where the flange diameter is larger than the outside diameter of the adjacent pipe-covering, build-up pieces are made of asbestos felt encased in asbestos cloth (Navy Department Spec. 32C11, type D) secured by stitching to the inside of the cover. The halves of the cover may be fastened around the equipment by means of 1/16 inch diameter soft galvanized iron rope laced through brass or galvanized steel hooks or rings, or covers may be secured by snap fasteners. Fastenings fixed to cloth lagging must be backed up by washers on both sides of the cloth.

(2) A rigid cover made up of segments of block insulation of the same material used for pipe covering is shown in figure 39-6. Block is securely wired to frames of ½ inch square mesh of 18 gage (0.049 inch diameter) galvanized steel wire. The wire mesh frames inside and outside of the block insulation have the ends bent over and joints secured with 18-gage, black-annealed, iron wire woven through the mesh. Insulating cement of the same material as the blocks is trowelled smoothly over all surfaces of the mesh. Asbestos roll fire felt (Navy Department Spec. 32F1) may be used to build up the cover where the flange diameter is larger than the outside diameter of the adjacent pipe-covering. Covers should be lagged with asbestos cloth (Navy Department Spec. 32C11, type D) tightly and smoothly fitted to envelop the outside and ends.

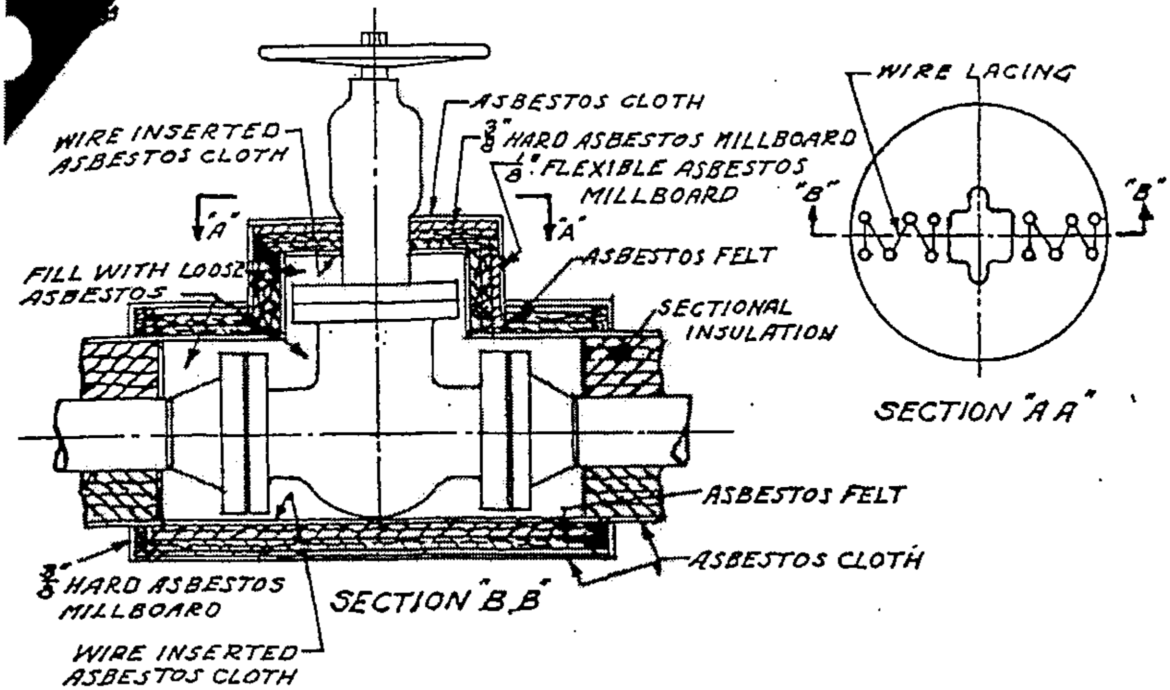

FIGURE 39-4

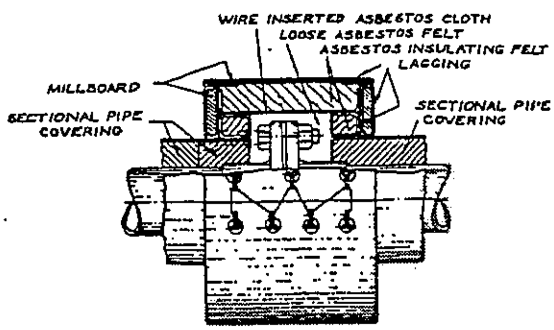

FIGURE 39-5

Where double layer insulation is used, the two sections of the cover should be fitted together with a scarfed joint. Care must be taken in the workmanship to insure straight and true jointing surfaces of the sections with the view of reducing the heat loss at the joints. Bands and eyelets of galvanized steel are used for securing the cover around the equipment.

(3) Rigid covers similar to those described in paragraph (2) above may be made of fibrous sectional pipe-covering (Navy Department Spec. 32P8, classes C and F) of the same thickness as that on the adjacent piping. The pipe-covering is strong enough so that the wire frames are not required. Lagging may be secured with an approved high temperature adhesive cement.

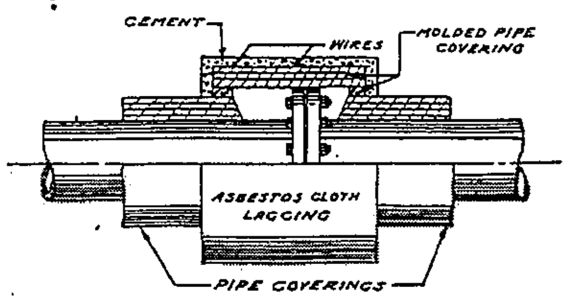

FIGURE 39-6

(4) Where the rigid covers described above are not practical, for example because of restricted space, flexible covers, as shown in Figure 39-7, may be used. These covers are similar to those described in paragraph (1) above except that the millboard is omitted.

(5) Flexible flange covers shown in figure 39-8 may be made as described below:

(a) A circular wooden form is first made up with a diameter equal to the flange diameter for which the particular cover is going to be made.

(b) The inner and outer covering of the flange covers are made of asbestos cloth. The inner cloth is laid over the form and accurately cut to the length

required with allowance for stitching so that the finished inside surface will be smooth and free from wrinkles.

(*c*) The end pieces of the cloth are cut circular to suit inside and outside diameters with the necessary allowance for stitching. The cloth cut in this form will eliminate puckers and wrinkles.

39–54.

Spaces between removable covers and the surfaces they insulate should be packed with pieces of asbestos felt to exclude all air possible. On covers which do not fit tightly about the adjacent pipe covering, spaces should be calked with suitable material such as narrow strips of asbestos cloth.

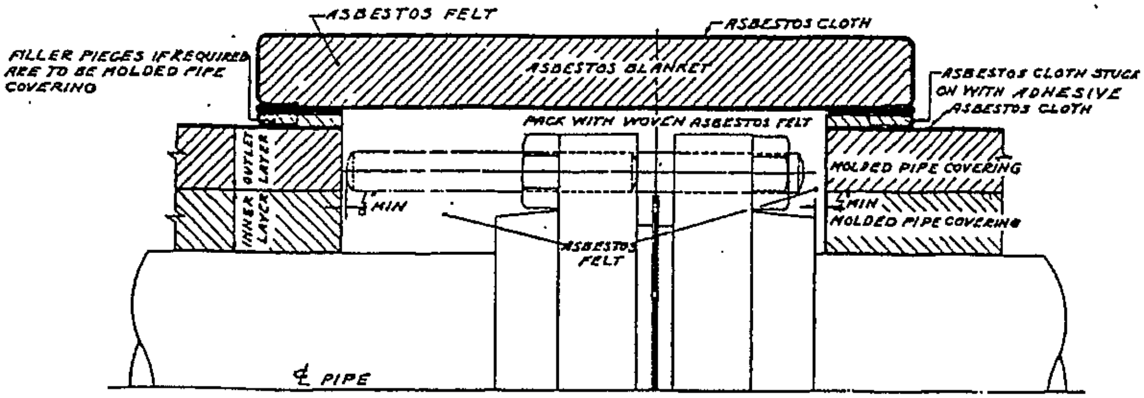

FIGURE 39–7

(*d*) The outside cloth covering is cut in the same manner as described in (*b*) above.

(*e*) The pieces of cloth are sewn together before filling with asbestos felt as much as it is practical to do so. Stitching is done from the inside where possible in order to improve the external appearance.

(*f*) Before filling the cover with asbestos felt, a $\frac{3}{16}$-inch diameter steel rod is inserted along the entire length of the outside lap of the joint. The rod is secured in place by stitching with asbestos sewing thread. This rod provides a straight hard edge at the outside of the lap, thus providing a greatly improved appearance and serving to hold the shape.

(*g*) A stiffener strip, which consists of asbestos cloth of the same type used for the outside covering, is placed under the outside covering; its width should extend far enough to include the lacing washers and rings. The strip is well soaked in silicate of soda or adhesive cement and allowed to dry prior to insertion in the cover. The strip will be reasonably rigid but flexible enough to bend to the curvature of the cover. This piece of cloth serves to stiffen the surface of the cover in way of the lacing rings, washers, and wire and eliminates the corrugations caused by them.

(*h*) The overlap is made to reduce the heat loss at the joint. It allows additional flexibility for drawing the ends of the cover together and provides a margin to take care of any difference in diameter that may occur.

39–55

The foregoing description of the use of removable covers is applicable to the latest construction. Existing installations need not be changed simply to conform to these requirements but changes made only when replacement is necessary.

39–56

Valves, fittings and flanges not included in article 39–52 may have permanent insulation; the following applies to temperatures of 100° F. and up:

(a) For sizes 3½ inches and under, an all cement insulation may be used. Apply insulating cement, usually in accordance with Navy Department Spec. 32C14, type B, in ½ to ¾ inch thick layers to cover the bodies, flanges, and bonnets. Each layer of cement must be permitted to dry before the next is applied. Heat should be applied from within as soon as practicable and within 24 hours after installation of the cement to dry out the insulation and avoid corrosion of the metal. After drying, a coating ½ inch thick of high temperature cement tempered with Portland cement or equal (4 parts cement to 1 part Portland cement) or a coating of asbestos finishing cement per Navy Department Spec. 32C16 is applied and trowel-rubbed to a smooth finish. Lagging should be in accordance with paragraphs 39–12 (3) or 39–12 (4). For temperatures from 100 to 500° F., magnesia plaster, Navy Department Spec. 32P10 described in paragraph 39–11 (19), may be used in lieu of high temperature insulating cement; however, this material is less strong and is more difficult to apply.

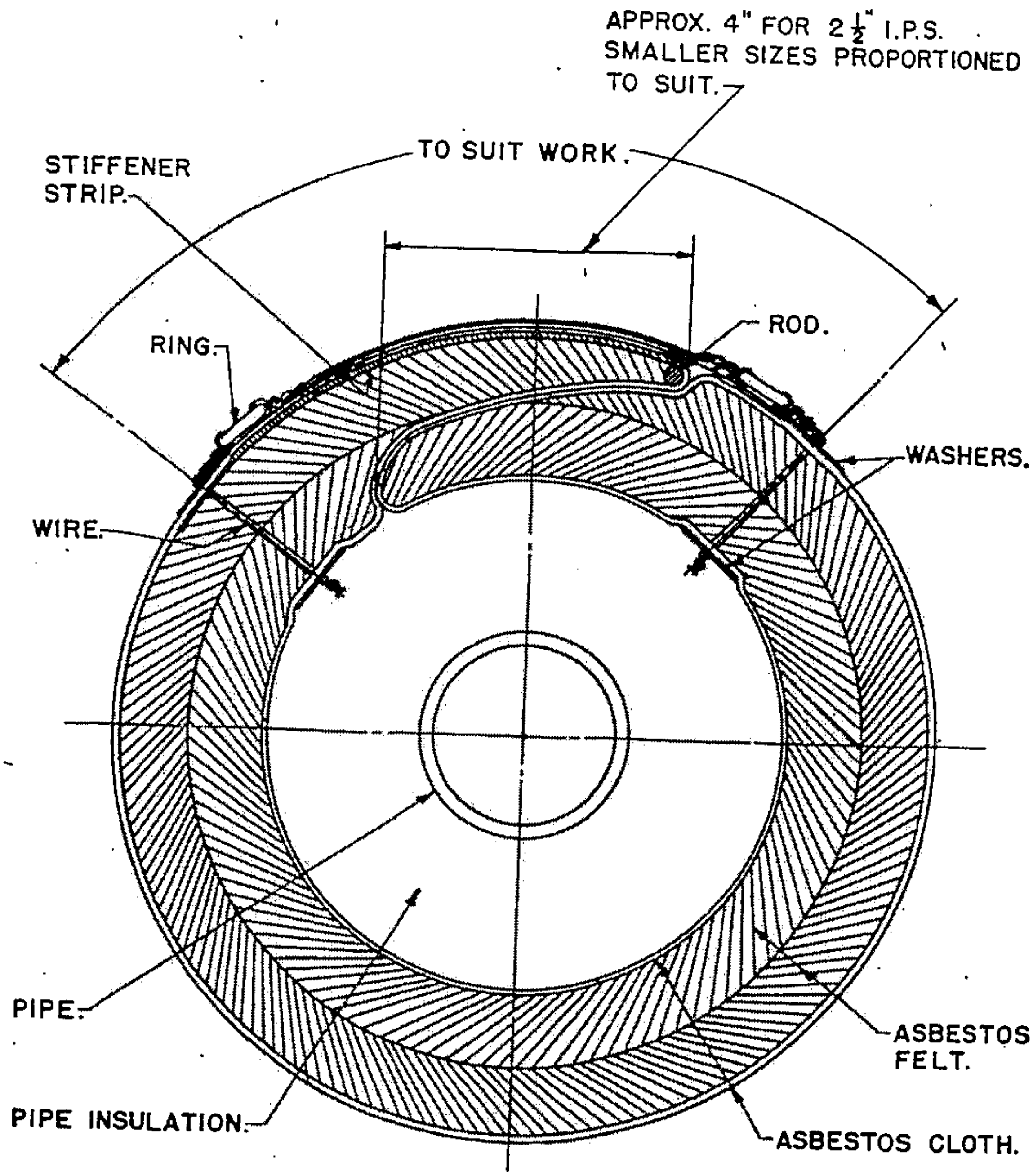
APPROX. 4" FOR 2½" I.P.S.
SMALLER SIZES PROPORTIONED
TO SUIT.
TO SUIT WORK.
STIFFENER
STRIP.
RING.
ROD.
WASHERS.
WIRE.
PIPE.
ASBESTOS
FELT.
PIPE INSULATION.
ASBESTOS CLOTH.

FIGURE 39–8.

(*b*) A method similar to that of paragraph (*a*) above but having a form of wire-reinforced asbestos cloth, Navy Department Spec. 32C11, type c, over which the cement is applied is shown in figure 39-9. Spaces around the bolts should be packed with asbestos felt.

(*c*) All sizes may be insulated by cutting asbestos felt, per type A of Navy Department Spec. 32F3, in suitable widths and building up the thickness required to match the adjoining pipe covering allowing for ½ inch of finishing cement. On valves and fittings the felt should be carried over the flanges to the end of the sectional pipe covering. Spaces that cannot be filled with the layers of material should be completely filled with loose asbestos felt. Fix the first layer of asbestos to the metallic surface with adhesive cement, preferably of the type described in paragraph 39-13 (3). Layers of felt are secured in position with black or galvanized iron wire and overlaid with 1-inch-square wire mesh. A ½-inch layer of cement as described in paragraph (*a*) above is applied. Lagging should be in accordance with paragraphs 39-12 (3) or 39-12 (4). See figure 39-10.

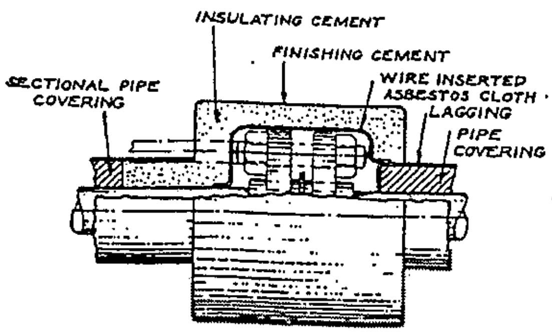

FIGURE 39-9.

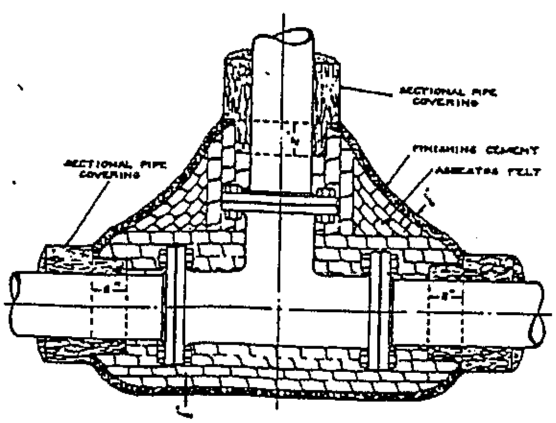

FIGURE 39-10.

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39-57

Valve bodies and fitting bodies may be permanently insulated as described in paragraph 39-56 (*c*) but the felt is not carried over the flanges; the latter are insulated with removable covers.

39-58. COLD WATER AT ALL TEMPERATURES

Valves, fittings, and flanges for cold service do not have removable covers because the insulation must be tight against the penetration of moisture. The following methods are used:

(*a*) Insulate in a manner similar to that described in paragraph 39-56 (*c*) using either plain or water-repellent asbestos felt per Navy Department Spec. 32F3. Wire should be galvanized. Felt need not be covered with finishing cement. Place a layer of water-repellent and flame-proof sheathing paper, which is described in paragraph 39-12 (7), over the felt; paper should be mitered, lapped, and fitted carefully. Use adhesive cement per type B of Navy Department Specification 52C23 to secure and seal the paper. Lagging should be the same as used on the cold pipe; see paragraph 39-39 (1).

(*b*) Insulate as described in paragraph (*a*) above but use mineral wool pipe covering instead of asbestos felt.

39-59 REFRIGERANT

For temperature of 36° F. and over the methods described in article 39-58 or molded cork may be used. Below 36° F. molded cork valve, fitting, and flange covers must be used for insulating refrigerant lines. Covers should be of the same thickness as adjacent pipe insulation. For the most generally used sizes, valve and fitting covers are furnished in two sections. The method of application outlined in paragraph 39-40 is used. Sections of cork covering made for pipes should not be mitered to form makeshift covers for elbows or other fittings. Flanged fitting covers are applied after covering has been installed on the piping and rest upon the outside of the pipe covering. For other than flanged fittings, the covers are wired on first and the straight pipe insulating material is wedged in tightly between the fittings. To make the cork fit properly, cut the straight pipe covering rather than the fitting covers. Make cuts square to secure tight joints. Carefully wire the covers in place using not less than four 12-gage, copper-clad, steel wires for each soldered fitting, and not less than six wires to each flanged fitting. Cement filler and putty used in commercial application of cork insulation must not be used because such materials are flammable.

Part 6.—Application of Thermal Insulation to Machinery

39-71. RECIPROCATING ENGINES

(1) Propulsion reciprocating engine steam cylinders, valve chests, and other steam enclosing sur-

faces are insulated with 85 percent magnesia or asbestos blocks which are described in paragraph 39-11 (9). High-pressure cylinders and valve chests should have insulation 3 inches thick applied in two 1½-inch layers. For intermediate pressure cylinders and valve chests, use 2 inches of insulating material and for low-pressure cylinders and valve chests use 1 inch. The blocks should be carefully fitted to the metallic surface. Where there are two layers, all joints should be staggered. The blocks should be firmly fastened in place with ⅛-inch galvanized steel cables spaced on 9-inch maximum centers. 1-inch mesh, galvanized, wire netting of 18-gage wire is then spread over the surface and held by wiring to the steel cables. All joints should be neatly pointed and smoothed with magnesia cement per paragraph 39-11 (19) or high temperature cement per paragraph 39-11 (18), and a layer just thick enough to cover the netting and tie wires completely should be trowelled on smoothly. Cylinders and valve chests are neatly lagged all over with 24-gage, galvanized, sheet steel per paragraph 39-12 (10). Upper cylinder heads are insulated as described above but are arranged with cast-iron plates with nonslip upper surfaces instead of sheet-metal lagging. Metal lagging may be secured by using lap joints with a bead on the exposed edge, fastened with hardened self-tapping screws making their own thread in punched holes. See figure 39-11.

(2) Auxiliary reciprocating engines may be insulated as described in paragraph 39-71 (1). Asbestos felt per paragraph 39-11 (13) may be used in place of blocks if it is considered more practicable.

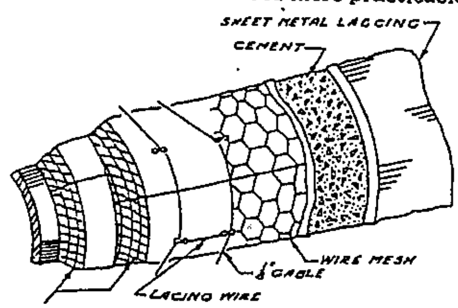

FIGURE 39-11

39-72. TURBINES

All surfaces of propulsion and auxiliary turbines which have a maximum operating temperature of 100° F. or more should be insulated by one of the methods described in this section. Thickness of insulating material should be as shown in table VI.

(1) Surfaces which can be permanently insulated may be covered with sufficient layers of asbestos felt per paragraph 39-12 (13) to make up the required thickness. Joints of adjacent layers should be staggered. Layers of felt may be held to one another with adhesive cements per paragraphs 39-12 (2) and 39-12 (3). Felt should be firmly secured with ⅛-inch, flexible, galvanized, steel cable spaced on 9-inch maximum centers around the outside layer. The cable may be fastened to steel hooks welded to the casing where required. No holes should be drilled in the casing. One-inch mesh netting of 18-gage, galvanized, steel wire is spread over the felt and secured by 18-gage wire to the cables. A ½-inch thick coating of finishing cement (32C16) or of insulating cement per paragraph 39-11 (18) tempered with Portland cement or equal (4 parts insulating cement to 1 part Portland cement) is applied over the netting and trowel rubbed to a smooth finish. After drying 24 hours, an adhesive insulation cement per paragraphs 39-12 (2) or 39-12 (3) is applied to the hard cement finish and allowed to dry for 1 hour, after which a second coat of the same cement is applied and allowed to dry. Lag the insulation with glass cloth or asbestos cloth of the correct type indicated in paragraph 39-13 (3). Galvanized steel rings backed up by galvanized steel washers fastened on both sides of the lagging should be attached to the permanent insulation adjacent to removable blankets. These blankets are used to cover the flange joint between the upper and lower casings. They are formed by quilting layers of asbestos felt together with fine nickel copper alloy or brass wire or asbestos twine per paragraph 39-12 (3). The turbine side of the blanket is covered with wire-inserted asbestos cloth and the outer surface is covered with plain asbestos cloth of the type recommended in paragraph 39-12 (3).

Blankets are secured to the permanent insulation with 18-gage, galvanized iron or copper wire laced through metal hooks or eyes attached to the edges of the blankets and the rings on the permanent insulation. It is preferable that blankets should project well over the insulation of the adjacent surface. Blankets should be shaped to fit accurately, and spaces between them and the hot metallic surfaces should be completely filled with loose asbestos. (See fig. 39-12.)

(2) Another method is to use the same procedure outlined in paragraph (1) above with mineral wool blanket insulation per paragraph 39-11 (15) instead of asbestos felt for both permanent and portable insulation. Removable blankets made with mineral wool should be covered with ¼-inch of asbestos roll felt per paragraph 39-11 (12) previous to enclosing them with asbestos cloth.

(3) Thermal block insulation per paragraphs 39-11 (9) and 39-11 (10) may be used for permanent insulation. Prior to applying the block, all irregularities of the turbine surface should be filled to form a smooth surface. Use magnesia or preferably high temperature cement for temperatures below

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500° F. and high temperature insulation cement for higher temperatures. Magnesia plaster or insulation cement should be used to point up joints between the layers of block and all crevices should be filled. The block covering is held in place by ⅛-inch, flexible, galvanized steel cable spaced on 9-inch maximum centers. The cable may be fastened to steel hooks welded to the casing where required. One-inch mesh netting of 18-gage, galvanized steel wire is spread over the outer layer of block and secured by 18-gage wire to the steel cables. Finishing cement and lagging are applied as described in paragraph (1) above. Removable insulation also is the same as outlined in that paragraph.

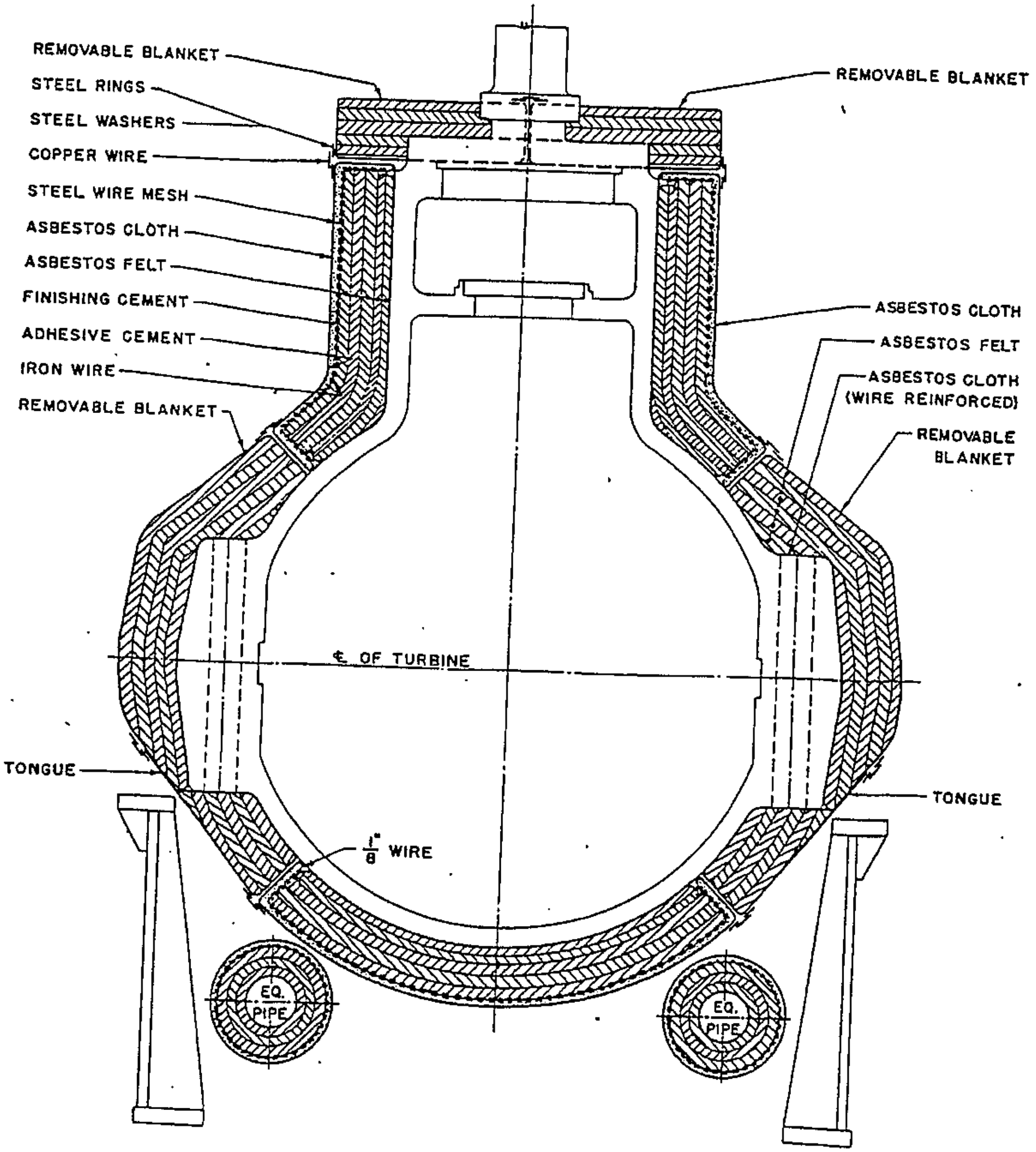


FIGURE 39–12

(4) Mineral-wool high-temperature insulating cement, as described in paragraph 39-11 (18), is sometimes used to form the complete permanent insulation. It is applied in layers less than 1 inch thick and is reinforced with wire mesh. Each layer must be permitted to dry thoroughly before applying more cement. Finishing cement and lagging are applied as indicated in paragraph (1) above. Removable insulation is the same as outlined in that paragraph.

39-73. BOILER STEAM DRUMS, WATER DRUMS, AND HEADERS

For insulation of boiler casings and refractory linings see chapter 51. See table VI for thicknesses of insulation:

(1) Drum shells may be covered with sufficient layers of asbestos felt per paragraph 39-11 (13) to make up the required thickness. The method described in paragraph 39-72 (1) should be followed. Figures 39-13 and 39-14 show a typical installation including the manhole cover of asbestos felt enclosed in a container made of 16-gage sheet metal per paragraph 39-12 (10). Sometimes metallic lagging of 20-gage, galvanized sheet steel is used in lieu of asbestos cloth, as shown in Figure 39-15. The sheet steel is fastened with ¼-inch machine screws to ¼- by 1-inch flat bars bent to a suitable radius and imbedded in the finishing coat of cement.

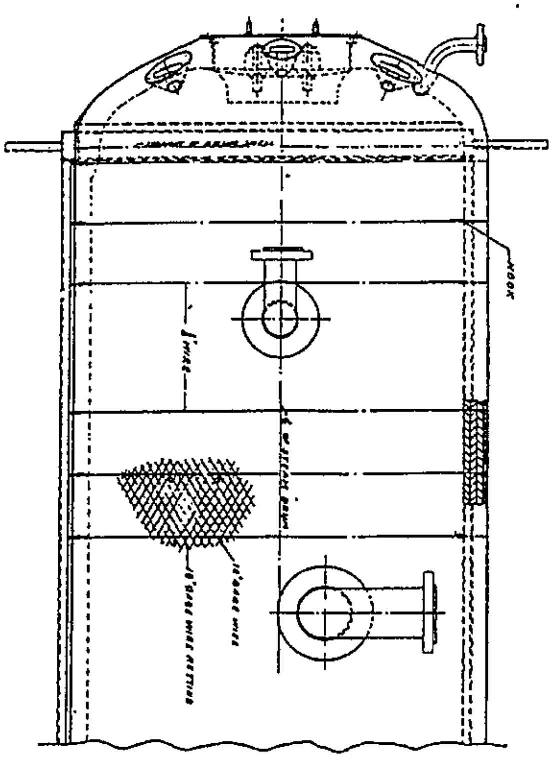


FIGURE 39-13

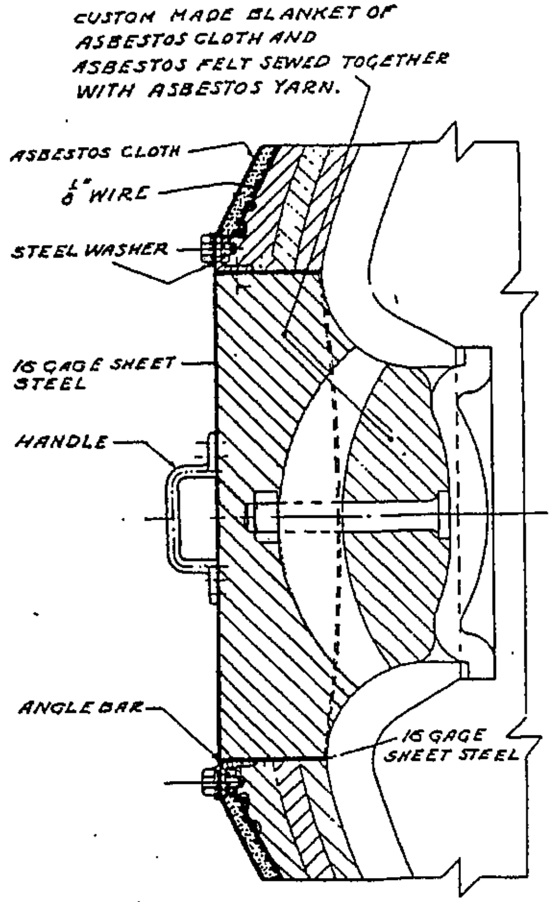


FIGURE 39-14

(2) Another method is to follow the procedure outlined in paragraph (1) above, but using mineral-wool-blanket insulating material per paragraph 39-11 (15) instead of asbestos felt. The type secured between 1-inch wire mesh and expanded lath should be used; the latter side should face outward. The drum ends may be insulated with high-temperature insulation cement of the rock or mineral-wool type described in paragraph 39-11 (18). Each layer of cement should be between ¾ and 1 inch thick and allowed to set for 24 hours or till dry. The manhole cover and the lagging should be of the type described in paragraph (1) above.

(3) Block insulation may be used for drum shells. Materials are described in paragraph 39-11 (9). Also large-size segmental pipe covering may be used. Application of this type of insulating material is outlined in paragraphs 39-71 (1) and 39-72 (3). The drum heads may be insulated with asbestos felt as described in paragraph (1) above or with cement as described in paragraph (2) above.

(4) Superheater headers may be insulated with custom-made blankets of asbestos felt enclosed in asbestos cloth. These blankets are laced to studs welded to the superheater support plate. Downcomer tubes and soot-blower piping should be insulated in accordance with part IV covering pipes and tubing.

39–74. UPTAKES

(1) Uptakes and breechings are constructed with an inner and outer casing between which the insulating material is placed. Glass fiber batts of 6-pound density described in paragraph 39–11 (14) may be used. It may be secured in place by wiring it to T bars which are suitably spaced and attached to the inner casing. Also it may be secured by impaling it on studs used to support the outer casing. Washers made of asbestos millboard per paragraph 39–12 (8) may be placed on the studs to hold the batts in place until the outer casing is installed.

(2) Mineral wool blanket insulation per paragraph 39–11 (15) also may be used for insulating uptakes. It should be wired in place with separate pieces butted closely together.

39–75. LOW PRESSURE DISTILLING PLANT

(1) The evaporator shells and the upper half of the evaporator ends, the vapor feed heaters, and air ejector condensers are permanently insulated with asbestos felt and cement with lagging in the manner described in paragraph 39–72 (1). The lower half of the evaporator ends should be covered with removable asbestos felt blankets of the type discussed in paragraph 39–72 (1). Refer to table VI for recommended thicknesses of insulation. The removable blankets may be fixed to 22-gage, galvanized sheet steel covers made in sections to suit the installation. Sections are held together and to the evaporators with ¼-inch machine screws or self-tapping screws. The blankets are secured to the metallic lagging by 18-gage, galvanized iron, or copper wire through rings attached to the blankets and hooks welded to the steel lagging.

(2) The condensate cooler should be covered as is required for cold water service. Use a 1-inch layer of asbestos felt and cement the same as on above apparatus. Over the cement apply one layer of water repellent and flameproof sheathing paper with vapor seals as instructed in paragraph 39–39 (1). Lag with asbestos or glass cloth.

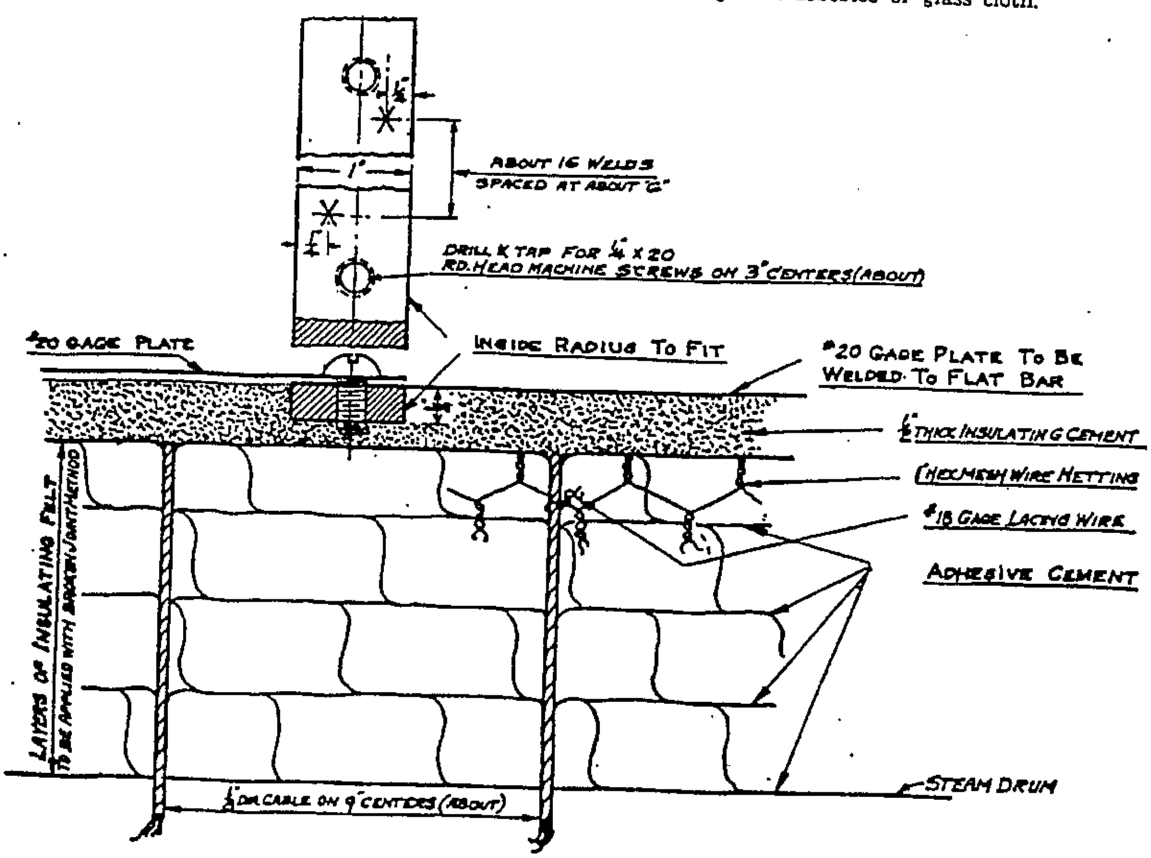


FIGURE 39–15

SECTION II—HULL INSULATION

Part 1.—Scope

39-101.

The thermal insulation discussed in this section differs from that in the first section, which covered the insulation of heat-producing equipment, by being concerned with the insulation of the structure of ships and their ventilating systems to improve habitability aboard ship. In the text which follows, the principles which guide the Bureau in establishing policies for the utilization of hull insulating materials are briefly reviewed and the consequent instructions are set forth as to the insulating materials to be used, where and how they are to be installed, and how repaired.

Part 2.—General

39-111. DEFINITION

Thermal hull insulation embodies the application of material, having high resistance to the flow of heat, to the surface of structure and other panels having relatively low resistance to the flow of heat. Thermal insulation differs from acoustical and electrical insulation, which are applied to retard the flow of sound and electricity, respectively. However, in some instances where acoustical insulation is installed, the application of additional thermal insulation is not necessary.

39-112. NEED FOR INSULATION

(1) Living and working compartments exposed to the weather are protected from the extremes of temperature due to the seasons, latitude, and time of day. Compartments adjacent to the propulsion and other machinery spaces and uptake enclosures are protected from the high temperatures prevalent in those spaces. Protection of spaces from their adverse surroundings is accomplished best by the complementary use of insulation and ventilation. The insulation retards the flow of heat into or out of the space, and ventilation removes excess heat or supplies heat to the space. Occasionally, it is possible to maintain the desired temperatures within a compartment by the use of either insulation or ventilation alone. In the interest of weight saving and reduction of construction and maintenance costs, this procedure is followed where it accomplishes the desired results. In most instances, however, both insulation and ventilation are utilized.

(2) The temperatures which ventilation and insulation are designed to maintain in Naval vessels, and a method of determining heat losses and quantities of ventilation and required thicknesses of insulation are included in the General Specifications for Building Vessels of the United States Navy, as modified by the detail specifications for a given ship.

(3) Different exposures and heat sources (chiefly personnel and equipment) affect the quantity of air to be circulated. Without thermal insulation, excessively large quantities of air for either heating or cooling would be necessary. Insulation on ducts of ventilation systems is often necessary to limit gain or loss of heat from the air in the ducts or to prevent condensation.

39-113. THICKNESS

(1) The rate of heat flow through a homogeneous insulation is in inverse proportion to the thickness. When installed, however, the insulation can no longer be considered as homogeneous since the structure to which it is secured and the air films on either side of the composite bulkhead-and-insulation or deck-and-insulation must be considered. Because of this, equal increments in the thickness of insulation do not yield equal reductions in rate of heat transfer. Practically, this consideration means that small variations of insulation thickness do not materially affect the rate of heat flow and, therefore, the corresponding air volumes required. As a result, it has been possible to adopt uniform thicknesses of insulation for varying rates of heat transfer at different temperature levels. The thicknesses in general use are:

(*a*) *One inch.*—For all spaces requiring insulation where exposed to water or the weather, for insulated boundaries of mechanically cooled spaces, and for surfaces on which insulation is used as a fire retardant medium.

(*b*) *Two or three inches.*—Where required adjacent to heat-producing spaces, such as propulsion and distilling machinery, trash burner rooms, and certain workshops.

(*c*) *Six inches.*—For refrigerated spaces.

(*d*) *Five-eighths of an inch.*—For ventilation ducts requiring insulation.

(2) Occasionally, other thicknesses are installed to meet special conditions. As an example, on destroyer-type vessels, where weight is a primary consideration, ¾-inch thick board is used in lieu of 1-inch board. If there is any doubt as to the thicknesses of insulation to be installed when replacing insulation, the insulation plans for the vessel should be consulted. For new designs the thicknesses of insulation are designated in the detail specifications for the particular vessel. In the absence of any specific instructions, the use of thicknesses given above is acceptable.

39-114. SWEATING

An outstanding instance wherein increased ventilation cannot always compensate for a deficiency in insulation is in the "sweating" of surfaces. Condensation of moisture occurs when the temperature of the surface is at, or below, the dew point of the contiguous air. In most instances the temperature on the warm side of a boundary of a cooled space

can only be elevated sufficiently to prevent condensation by providing adequate thickness of insulation. For this reason, additional insulation is generally installed on the underside, and occasionally on the warm side of bulkheads of refrigerated spaces. Under extreme continued high differentials between space dew point and metal surface temperature, the insulation so installed, regardless of thickness, may not be adequate to prevent condensation and corrosion of the metal surface.

Part 3.—Hull Thermal Insulation

39-121. APPLICATIONS

The insulation which is applied to the shell, bulkheads, deckheads, and the stiffeners and beams of these structural components of a vessel's hull is here termed "hull thermal insulation" to differentiate it from the thermal insulation applied to equipment, cold storage spaces, and the ducts of ventilation systems. The insulation is installed in the locations and thicknesses enumerated in Section L-2 of the General Specifications for Building Vessels of the United States Navy and in the detail specifications for the particular vessel. Where it is necessary to install hull insulation on the stiffener side of bulkheads, on the shell, on the underside of weather decks, or on overheads in machinery spaces, the exposed webs and flanges of the stiffeners (frames or beams) are in many instances also covered, or partially covered, with insulation.

39-122. MATERIALS

(1) Hull insulation used on naval surface vessels consists of fibrous glass board conforming to Bureau of Ships Spec. 32-G-8 (INT). The board is faced with a layer of treated and hardened fibrous glass cloth which provides a rigid, damage-resistant surface. Fibrous glass stripping tape, for covering and sealing the seams formed by the adjacent 24- by 36-inch panels of board, is included in the same specification. Both board and tape may be easily cut to fit any shape or contour of the structure. Fibrous glass board is attached to vessel's structure by use of cement conforming to Navy Department Spec. 52C23, and by use of threaded studs welded to the structure, over which the board is placed. The board is secured by washers and nuts. The purpose of the cement, which is provided in two types, A and B, is to secure the tape, to seal the seams of adjacent panels to prevent glass fibers from escaping and moisture from entering, and, when applied to the back of the board, to prevent the board from shifting in service. Type A cement is used on the back of the board. Type B cement is used to fill the seams and secure the tape over the seams. It may also be used on the back of the board when the air temperature is above 40° F. Below that temperature, type B cement will not perform as well as type A cement.

(2) A complete description of the welding attachments for securing the board in place rapidly and in a manner to resist all vibrations and other shocks which might dislodge it, if secured with cement alone, is given on Bureau of Ships Drawing 692SK2742 (fig. 39-21). Various studs for securing insulation to medium, high tensile, and special treatment steel and to armor plate are shown thereon, as are also drawings of the welding ferrule which must be used to insure satisfactory welds, and the special washer and nut which secure the insulation. Studs for welding to medium, high tensile, and special treatment steel no greater than ¾-inch thick are of low carbon steel (SAE 1010). They are designated as types A and B in figure 39-21. For welding to special treatment steel greater than ¾-inch thick and to class A and B armor, another low-carbon stud, designated as type C, is used.

39-123. INSTALLATION

(1) The first step in installing hull insulation is to inspect the steel to which it is to be applied for corrosion. It is important that the protective coating be intact to prevent subsequent corrosion of the metal by moisture which may penetrate through the board to the steel. Where necessary, the steel surface should be touched up with zinc chromate primer. Before any board is installed the surfaces should also be free of any grease or dirt. At the time the surfaces are inspected, measurements should be made of the stiffeners whose flanges and webs are to be insulated. Prefabrication of insulation into wrappings has been found to be the best method of covering stiffeners, since a minimum of cutting and fitting is thereby required, and sections of stiffeners are insulated in one operation. The method consists essentially of cutting V grooves, properly spaced, on the back of the insulation board, removing the loose strips of board where the intersecting cuts meet just below the cloth facing, and then bending to shape for fitting around the flanges. Descriptions of equipment which has produced good results were published in the July 1946 issue of Bureau of Ships Shop Notes.

(2) These are two acceptable methods for securing the board to the structure. In one, the studs are laid out and welded in place on the structure, with due regard to the number required and dimensions and contour of the section of board to be installed. The board is then daubed with cement on the back and coated heavily on all edges, and is then impaled over the studs. The other acceptable method differs in that each section of board is first fitted into place, and locations of the studs determined by punching through the board to mark the steel. The board is then removed, the studs welded, the board cemented as above, and then slipped over the studs through the holes previously formed. In both methods, after the board is in place and pressed

firmly against the structure, the washers and nuts are secured over the stud, as shown in figure 39-21, to hold the insulation permanently in place. In either of the two acceptable methods, sufficient studs must be used to hold the board firmly and evenly against the structure. In all instances, it is imperative that each welded stud be tested to insure that the weld is sound and will not fail in service. Each weld is to be tested by slipping the special tool shown in figure 39-21 over the stud as far as it will go, and bending once through an angle of 15° and return.

(3) In both methods of installation the seams may be filled with cement after the boards are installed in lieu of coating the edges forming the seams at the time the board is set in place. When this is to be done, a gap of not more than ⅛ inch should be left between each section of board as it is set in place, and the seams calked with the equipment shown on Bureau of Ships Drawing 631SK23 (fig. 39-22). Sealing seams in this manner is restricted to the use of type B cement and an ambient temperature of more than 40° F., since type A cement will not operate well in calking equipment.

(4) Until a stud for welding to aluminum structure is available, insulation should be secured to aluminum structure by impaling the board over split galvanized clips which have been riveted to the aluminum structure at their unsplit ends. A washer, similar to that shown on figure 39-21, is slipped over the free end of each clip after the board is in place, and the split ends of the clip are then bent in opposite directions flat against the washer.

(5) Types A and B studs are stud-welded by use of a special welding gun in which the stud acts as the electrode through which current is passed for a brief interval as the gun is held away from, and then pressed against, the structure. When the current is released and the gun drawn away, the stud is released from the gun and remains affixed, welded, at right angles to the structure. Type C stud is secured by manually arc-welding a fillet weld around the base of the stud.

(6) In those instances where stud welding is used, it is recommended that it be done with automatic welding equipment, by which the duration of the welding current and length of arc forming the weld are preset and mechanically controlled. In this manner, variations in the judgment and skill of welders are eliminated and the probability of securing uniformly sound welds is increased. It is acceptable to form the welds by the simpler type of stud welding gun, which requires manual control of the length of arc and duration of welding current. It is mandatory, however, that each weld be tested as described above regardless of the equipment used to form the weld.

(7) No sheathing is permitted over any fibrous glass board hull insulation. In the past, sheathing has been permitted because the face of the board was not very hard and was, therefore, susceptible to injury. Fibrous glass board conforming to Bureau of Ships Spec. 32G8 (INT) is tough and resistant to almost all forms of damage. It, therefore, does not require any sheathing. After the board is installed it should be painted to match the other surfaces in the compartment.

39-124. INSPECTION

Hull insulation should be inspected at least at semiannual intervals together with other portions of the hull structure. Action should be taken to have all damage, including that considered as minor, repaired at once since prompt repair will forestall development into major repair jobs.

39-125. REPAIR

(1) Two procedures for repair of damaged fibrous glass board insulation have been established; one for accomplishment by ship's forces, and the second by qualified repair activities. Each vessel fitted with fibrous glass board insulation has been allowed a repair kit consisting of 8 rolls of fibrous glass tape and 2 gallons of type B adhesive cement for shipboard repair of small tears, dents, gouges, and similar damage to the insulation. Application of the tape will, in most instances, prevent further damage and insure the continued serviceability of the insulation until the next overhaul of the vessel when, if warranted, more extensive repairs can be made.

(2) For extensive repairs to the insulation, a method is available whereby in most instances the insulation may, in lieu of being replaced, be repaired economically and with facility, with a resultant condition at least equal to that of newly installed board. The method has been developed especially for the repair of soft-faced fibrous glass board, Navy Department Spec. 32G6, which was the type used prior to the introduction of the hard-surfaced board, specification 32G8. It is, however, fully applicable to the latter insulation.

(3) The method, which consists essentially of cementing a cloth covering (stock numbers 32-C-1928 and 32-C-1928-36) over the insulation, is based on the fact that most damage occurs initially to the glass cloth surface, and leaves the body of the board relatively intact. One gallon of cement (stock number 52-C-728-260) is required for each 40 square feet of cloth.

(4) Before the covering is applied, the damaged insulation is to be prepared as follows:

(*a*) Protect all free edges of insulation terminating at doors, air ports, and similar openings with an angle bar welded to the structure.

(*b*) Fill with cement all exposed seams around attachments through the insulation.

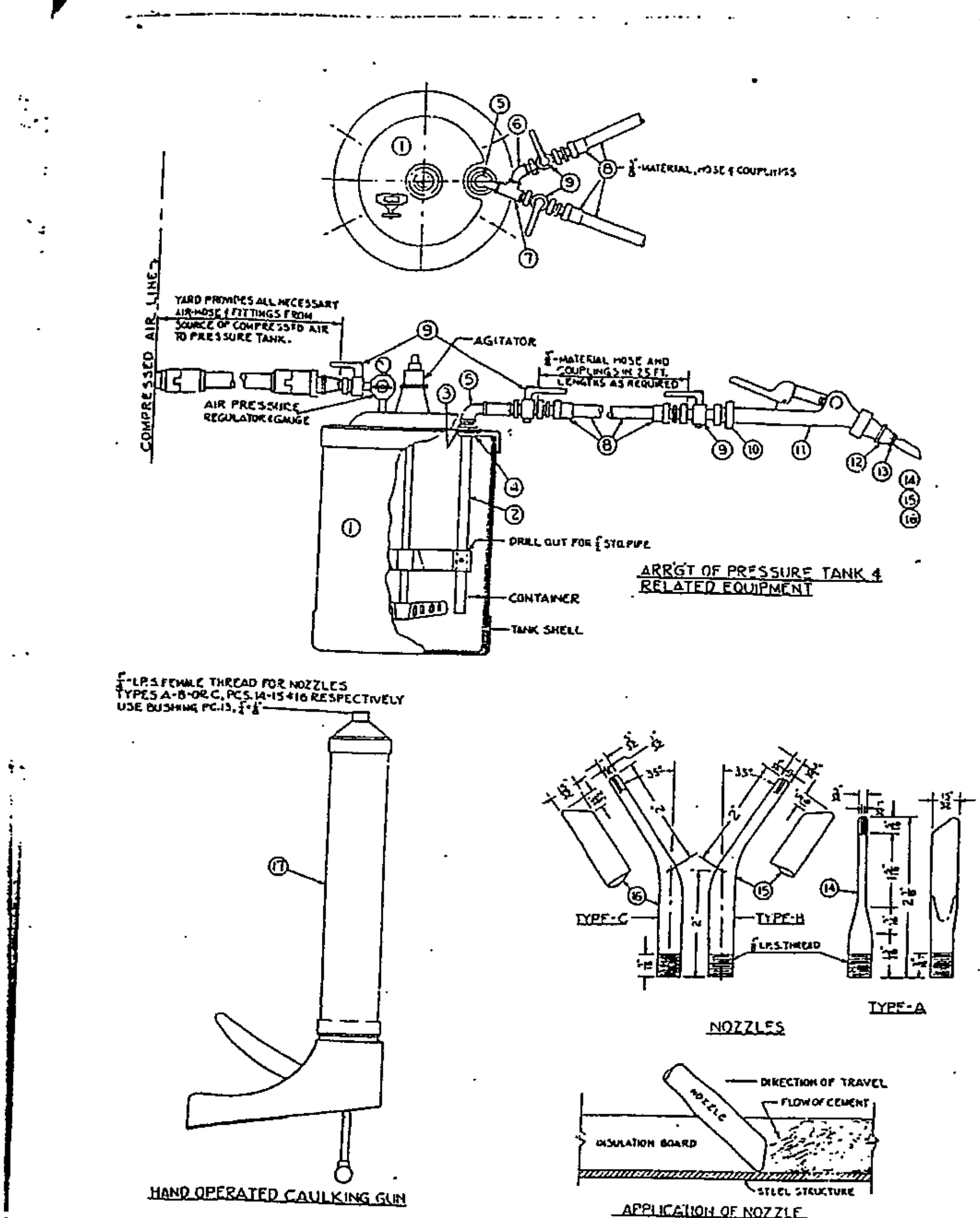


FIGURE 39-22

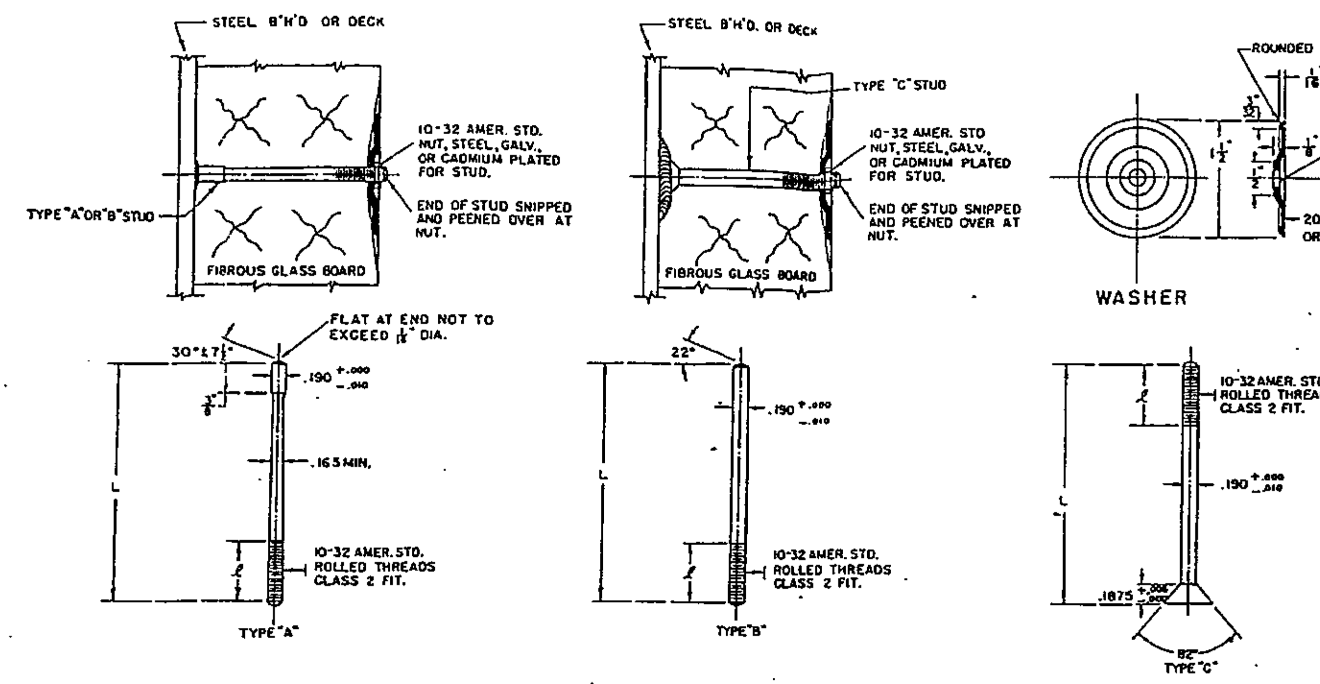
BILL OF MATERIAL

Item	Name	Number of pieces	Material and material specifications	Remarks
1	Pressure tank	1	Commercial	Bink's No. TU-5-78-82. (See General Note No. 2)
2	Material outlet pipe	1	Brass 44-P-12	3/8" I. P. S. standard pipe—L-14"—thread Abt. 1¼" Lg.
3	Washer	2	Leather 33-L-1	1¼" O. D. for 3/8" D. pipe.
4	Lock nut	2	Brass 45-N-1	For Pc. No. 2¼ D. pipe thread.
5	Street ell	1	Brass 45-F-2	90°-3/8" to 3/8" male end.
6	Street ell	1	Brass 45-F-2	45°-3/8".
7	Tee	1	Brass 44-P-2	3/8"-straight.
8	Hose and coupling	2	Rubber-Comp. commercial	Bink's No. H201—complete with No. SC-76 couplings.
9	Shut-off cock	4	Commercial	Bink's No. D1241-3/8".
10	Reducer coupling	2	Brass 45-F-2	3/8" to 3/8".
11	Flow gun	2	Commercial	Bink's model No. 12—minus nozzles—pieces 14-15-16.
12	Reducer coupling	2	Brass 45-F-2	3/8" to ¼".
13	Bushing	2	Brass 45-F-2	3/8" to ¼".
14	Nozzle—type A	2	Brass 44-P-12	Extra heavy—L-3¼"—see det.
15	Nozzle—type B	2	Brass 44-P-12	Extra heavy—L-4½"—see det.
16	Nozzle—type C	2	Brass 44-P-12	Extra heavy—L-4½"—see det.
17	Hand calking gun		Commercial	1 Kammer No. 22 R. T. T. bulk calking gun as furnished by Calber Paint & Varnish Co. Philadelphia, Pa.

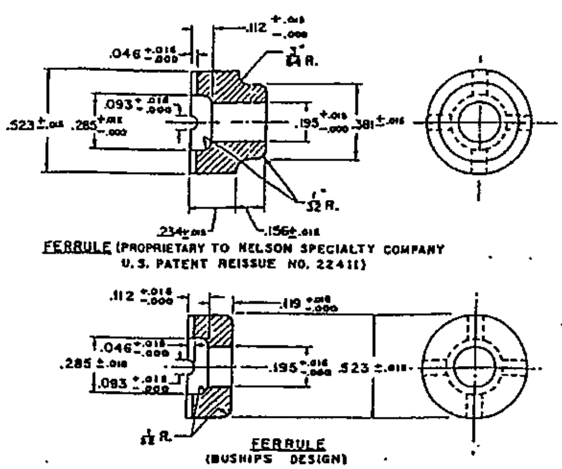
GENERAL NOTES

1. The equipment shown on this plan has been developed to calk seams in fibrous glass board insulation by injection of cement under pressure from a tank connected to a source of compressed air or from a hand operated calking gun.
2. Special equipment is available as noted from the Binks Mfg. Co. Chicago, Ill. and the Calber Paint & Varnish Co. Philadelphia, Pa., although equivalent equipment is acceptable. Piece No. 1 pressure tank, is equivalent to Binks Mfg. Co. No. TU-5-78-82 complete with pressure regulator, gage, safety valve relief valve, air motor agitator, and material container No. D-1546, less material outlet pipe and shut-off cock. Other items except the nozzles are standard. In any case all surfaces of metal parts should be galvanized or otherwise protectively coated against corrosion. Any items for which such coatings are not practicable should be of a noncorrodible metal to insure that the water contained in the cement will not rust the equipment thereby preventing its proper functioning.
3. Type B cement of N. D. Spec. 52-C-23 of 18 April 1945 is to be used to calk the seams. The nozzles have been especially designed for flow of this cement.
4. The pressure to be maintained in the tank depends upon several factors and should be so governed that a smooth unhurried flow is obtained at the nozzle outlet. Such pressures, controllable by the air shut-off cock or air regulator valve on the gage, will range from 45 to 60 pounds per square inch.
5. Operation of the hand calking gun is clear from its construction.
6. In operation, the pressure tank or gun is filled with cement and the end of the nozzle pushed into the seam until it makes contact with the steel for 1 inch thick insulation to insure that the entire seam is filled. On thicker material the nozzle should be inserted to a depth of 1 inch. The nozzle and gun should be held at an angle of about 45° with the hand. The offset nozzles are for use in seams in way of ship's structure. All nozzles should be moved along the seam with the opening discharging opposite to the direction of movement in order to prevent the nozzle from wiping out the seam as it is drawn along. Because of the tendency of the cement to drip, particularly from the overhead, it is important that another man follow the nozzle and brush the excess cement over the seam. The seam should be allowed to dry for about 24 hours after which tape is applied. All equipment may be cleaned by washing with water but should be dried immediately thereafter to prevent corrosion.

PRESSURE EQUIPMENT FOR CALKING SEAMS IN FIBROUS GLASS BOARD INSULATION

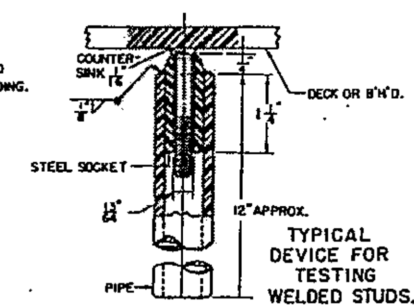


DIMENSIONS FOR STUDS		
INSULATION THICKNESS	DIM. "L"	DIM. "ℓ"
1/2"	1 1/4	1/2"
1"	1 1/2"	1/2"
1 1/2"	2"	1/2"
2"	2 1/2"	1/2"
3"	3 1/2	1/2"



NOTES

1. MATERIAL FOR TYPES A, B AND C STUDS TO BE S.A.E. 1010 STEEL.
2. MATERIAL FOR FERRULES SHALL BE HEAT-RESISTANT CERAMIC AND SHALL SATISFACTORILY SHIELD THE ARC DURING WELDING.
3. THE USE OF TYPES A & B STUDS IS OPTIONAL FOR ATTACHING INSULATION TO ALL THICKNESSES OF M.S. & H.T.S. AND TO S.T.S. NO THICKER THAN 3/4", BY STUD WELDING.
4. TYPE C STUDS SHALL BE USED FOR ATTACHING INSULATION TO CLASS A & B ARMOR & TO S.T.S. THICKER THAN 3/4", BY MANUAL WELDING.
5. ELECTRODES USED IN MANUAL WELDING TYPE C STUDS TO CLASS A & B ARMOR SHALL BE IN ACCORDANCE WITH GRADE IV-D.C. OR GRADE IV-A.C.-D.C. OF BUSHIPS SPEC. 46E4 (INT).
6. ALL WELDED STUDS SHALL BE TESTED BY SLIPPING A TESTING DEVICE SIMILAR TO THAT SHOWN OVER THE STUD AS FAR AS PRACTICABLE AND BENDING ONCE THRU AN ANGLE OF 15 DEGREES AND RETURN.
7. TOLERANCES SHALL BE ± 1/64" UNLESS OTHERWISE NOTED.



TYPICAL DEVICE FOR TESTING WELDED STUDS.

METHOD OF SECURING FIBROUS GLASS BOARD INSULATION TO STEEL DECKS OR BULKHEADS	CODE 692 SKETCH NO. 2742
NAVY DEPARTMENT, BUREAU OF SHIPS, WASHINGTON, D.C.	7 FEB. 1946

FIGURE 39-21

Exhibit C

9-21-46

A HEALTH SURVEY OF PIPE COVERING OPERATIONS IN CONSTRUCTING NAVAL VESSELS*

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AN INDUSTRIAL health inspection of an important U. S. Navy Contract Yard indicated that dustiness from miscellaneous pipe covering operations was considerable and that a few of the employees had what appeared to be asbestosis. This is a well-known industrial disease caused by only one thing—prolonged breathing of asbestos dust. The clinical manifestations are shortness of breath and an unusual chest picture by X-ray. In industry the disease is often disabling, but it is much less frequent than silicosis, with which it very properly is classed.

It was not felt that experience in a single yard was enough to justify any general statements on working conditions in other yards, and certainly was no cause for alarm, but the results warranted check-ups elsewhere. Accordingly, arrangements were made to examine by chest X-ray the pipe coverers in two Government Navy Yards, A and B, and in two Navy Contract Yards, C and D. Examinations were made of the working conditions including dust counts of the air breathed with microscopic and chemical analysis of the dust itself.

We would point out that this procedure is customary in making such surveys of occupational diseases—medical examination of the workers and a study of the nature and concentration of the contaminants in the air breathed.

PIPE COVERING MATERIAL

An important ingredient of pipe covering material used on U. S. Navy vessels is amosite. This mineral is a magnesium iron silicate of variable composition. The name is the generic one for an asbestos type of fibrous mineral mined in South Africa.

The chief reasons for the wide use of amosite felt and pipe covering in naval work are its low thermal conductivity, light weight, strength, and refractoriness. When the felt and pipe covering were first developed, we were still building vessels under the Washington Treaty of Limitations in Tonnage, and every pound saved meant that much more armor, guns or ammunition for a given displacement, to say nothing of more economic operation for the weight involved in insulation.

Amosite pipe covering weighs about 14 pounds per cubic foot, with a temperature limit of 750°F. as compared to magnesia with a weight of 16 pounds per cubic foot, and a temperature limit of 500° F. High temperature amosite pipe covering weighs about 18 pounds per cubic foot as compared to 26 pounds per cubic foot for other high temperature insulations. Because of the lower conductivity and the higher temperature limit of the amosite type, less of it need be used in a combination covering than other types of insulations.

The development of amosite felt started in 1934 when a need existed to secure a thermal insulation lighter in weight and thermally more efficient than the materials (blocks and cement or asbestos blankets) which were then being used on destroyer turbines. The Navy approved the type developed by a manufacturer in September, 1934. Originally amosite was used only for turbine insulation, but it proved so satisfactory that its field of application enlarged to include insulation of valves, fittings, flanges, etc. From the initial destroyer, it has been used on almost all the destroyers built since that time and on all other combat vessels built since before the War.

Pipe covering was a later development in late 1935 and early 1936. Due to the manufacturing problems involved, it took a longer time to evolve into a satisfactory shape, and its first use on naval vessels was in 1937. Since that time its use has spread markedly and it was used on the great majority of naval combat vessels built during World War II.

Water-repellent amosite felt was developed during the early part of 1942, as a replacement for hair felt in the insulation of cold water lines to prevent sweating. Hair felt had the disad-

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vantage of being combustible and as it was organic, when it became wet it moulded or rotted and could harbor vermin. At this time fires on board certain naval vessels convinced the Navy of the desirability of eliminating any combustible material from on board ship. Eventually water-repellent amosite was made in strips of 50 foot lengths and of suitable width to enclose the circumference of the pipe and enclosed in an extremely light-weight muslin to facilitate handling and reduce the dust, which the water-repellent agent accentuated.

I. Description of Operations and Working Environment

Asbestosis results from breathing asbestos fibers of relatively long length, such as 15 to 75 microns. It is not caused by breathing chopped up asbestos fibers of one or two microns (1). Therefore we are concerned with the presence in air of asbestos fibers which can be seen as such under low power of the ordinary microscope.

The clinical picture of asbestosis can easily be complicated by the presence of diatomaceous earth, a form of amorphous silica, which can cause silicosis and is probably a more serious health risk than asbestosis.

Another dust which may be present is magnesia, MgO, which is in very common use as a heat insulator and is harmless.

Therefore our analyses were done to indicate how much fibrous type of asbestos dust was present in the air breathed, how much silica was present (especially as diatomaceous earth), and how much of the harmless ingredients like iron oxide and carbonates.

Pipe covering may be divided into seven different operations as follows:

1. *Laying out and cutting*
2. *Band saw cutting*
3. *Sewing and preparation of boots and jackets*
4. *Cement mixing*
5. *Molding*
6. *Grinding*
7. *Installation on board ship*

1. *Laying out and cutting*

Rolls of the insulating felt are unwrapped and unrolled on a large layout table or on the floor of the shop. This material, with the exception of the type known as water repellent amosite, is then well wetted with a fine water spray. It is marked into measured sections and cut with a rotary electric hand saw. The cut sections are rolled up and either used immediately or stacked in the storeroom.

Usually one to three workers are employed at this operation. During the handling, unwrapping and unrolling of the asbestos, considerable dust arises, but appears to settle readily. A very fine water spray should be used for wetting down the material as a high velocity spray stirs up dust. Once it is wetted the handling and cutting of the material causes little visible dust. All of the four yards surveyed wet down the insulating material described above.

One Navy Yard has an elaborate exhaust system for the layout table. The entire top of this table is covered with small perforations through which the air is exhausted. This table is sufficiently large that no more than two-thirds of the top is ever covered with material and room air is thereby exhausted through the other third. While no velocity or capacity measurements were made on this system, data presented later in the report indicate that this control measure had a marked effect in reducing the dust count.

2. *Band saw cutting*

A standard band saw such as is found in wood-working shops is used to cut insulation blocks and boards into desired shapes. This operation produces large amounts of air-borne dust, most of which settles slowly. Normally there is only one worker on this operation at any one time.

Inasmuch as this is a very dusty operation, the band saw should be enclosed in a room by itself and should be equipped with adequate local exhaust ventilation both above and below the saw table. Because of the mechanical difficulties in locating this exhaust properly, some of the dust will escape into the air and the operator should therefore wear an approved dust respirator.

3. *Sewing and preparation of boots and jackets*

In this operation jacket covers for valves and pipe joints are fabricated. The work consists of cutting asbestos cloth with shears, padding the jackets with insulating material, and sewing with wire or asbestos cord. These operations give rise to only slight amounts of visible dust, and exhaust ventilation and respiratory protection are neither required nor used. There is usually a large number of workers doing this operation in one large room.

4. *Cement mixing*

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For protection and to give a neat appearance the insulation on board ship is usually covered with cement containing a high percentage of asbestos fibers. In mixing, the proper amount of water is added to the dry asbestos cement and thoroughly agitated with a hoe. Occasionally small amounts of asbestos cement are mixed in a pail with a trowel. Considerable dust is raised when the asbestos cement is dumped into the mixing trough and during the early stages of mixing. Ordinarily this process is done in a separate room and only one operator is exposed. The dustiness of this operation warrants the use of exhaust ventilation or respiratory protection or both, although ~~neither is~~ generally used.

Petrographic analyses of asbestos cement indicate that the amount of diatomaceous earth may be as high as 87 per cent by count.

5. *Molding*

Molding is the process of building up the insulation to fit odd shapes of boilerwork and piping. A form is made to the exact shape of the part to be insulated. Block insulation is laid on, adjoining sections glued together, exposed surfaces sealed with asbestos cement and the whole mold covered with asbestos cloth. When dry, the molded insulation can be lifted off the form and is ready to be installed on board ship. This operation is usually done in the shop next to the sewing operation. Very little dust is produced from this operation and no special ventilation or respiratory protection is required.

6. *Grinding*

Several shipyards reclaim their scrap pieces of prefabricated sections of insulation by grinding up this material and using it in the asbestos cement, all of which contributes considerable dustiness. Normally this job is done at infrequent intervals and only one or two men are exposed, but the operation should be isolated, general room exhaust supplied and an approved respirator worn by the operator.

7. *Installation of pipe covering on board ship*

There are a number of operations involved in pipe covering on board ship. Insulation felt is wrapped and pounded tightly around large pipes and joints and fastened firmly in place with wire or asbestos cord. Pipes and boilers are covered with prefabricated sections, which necessitates some hand sewing to fit the sections. Ready mixed cement is applied to fill in spaces and give a smoother finish. Some insulation is wrapped with glass cloth or asbestos cloth for greater strength. The only operations that produce much dust are the wrapping and pounding of amosite and the sewing of sections.

Nearly all of the compartments on board ship are involved in this work, although most of it is concentrated in the machinery spaces. Usually the greater number of pipe coverers work on board ship and relatively few men in the shop. The spacing of workers ranges from one or two men doing a small job in a living space to as many as twenty or thirty men working on ten or more jobs in the engine room. Temporary exhaust ventilation is seldom used on board ship for pipe covering and very few of the workers wear respirators.

Because of the varied nature of pipe covering operations in ship compartments, general exhaust ventilation is to be preferred. If the compartment is large, such as the main engine room, five air changes per hour are needed. In small compartments, such as living spaces, ten to fifteen air changes per hour are required.

II. Composition of Materials Used

According to Navy Specification the rovings of asbestos insulating felt (amosite) shall contain not less than 95 per cent asbestos fiber of the following composition:

Silica (SiO_2) per cent minimum	47.5
Iron oxide (Fe_2O_3) per cent maximum	45.0
Magnesium oxide (MgO) per cent minimum	6.0

Typical analysis of the two types of asbestos fibers in general use are tabulated below:

	Chrysotile	*Amosite*
Silica (SiO_2)	39.05%	50.24%
Magnesia (MgO)	40.07%	3.96%
Alumina (Al_2O_3)	3.67%	
Ferric oxide (Fe_2O_3)	2.41%	7.50%
Ferrous oxide (FeO)		32.00%
Sodium oxide (Na_2O)		2.12%
Combined water (H_2O)	14.48%	3.00%

Therefore amosite alone will not comply with Navy Specifications because of the low magnesia content and must be mixed with chrysotile asbestos to equal or exceed the 6.0 per cent minimum value for magnesia. On the other hand, chrysotile cannot be used alone because of its silica content which is below the minimum 47.5 per cent specified by the Navy. The two types

of asbestos fibers must be mixed together in the proper proportions to satisfy the values set for magnesia and silica. The amounts of these materials used to form this mixture therefore would be 6–43 per cent chrysotile asbestos and 94–57 per cent amosite asbestos.

These two fibers differ mainly in their physical characteristics. Chrysotile is capable of being readily separated into very fine fibers with a soft silky feel, whereas amosite is harsher and requires more manipulation to fiberize it. One authority has stated that the chrysotile has the finest individual fibers, and amosite the coarsest. Because of this difference we may suspect a decided decrease in the number of respirable fibers (below 200 microns in length and 5 microns in diameter) whenever amosite is used in preference to chrysotile asbestos.

III. Pipe Covering Facilities at Individual Shipyards

U. S. Navy Yard A.

There were 84 men working in the shop and 467 men on board ship. The shop was divided into two rooms, one of which was primarily for storage and occasional grinding and band saw cutting operations. The only mechanical exhaust ventilation in the shop was provided for the grinding, mixing and band saw cutting operations and was inadequate. In the other room layout, cutting and sewing were done with a small amount of space for storage. Cross draft ventilation was provided by open windows on both sides of the room.

Work on board ship was not supplied with exhaust ventilation.

No asbestos workers were found wearing respirators.

U. S. Navy Yard B.

There were 80 men working in the shop and 700 men on board ship. The shop was divided into four main rooms: Layout, Sewing, Cement, and Storage and Band saw combined. With the exception of the Cement Room, the doors between these were normally left open.

The work in the Sewing Room consisted mostly of fabricating and sewing valve boots and jackets. All the cement used on board ship was mixed in the Cement Room. There was no exhaust ventilation for either the Sewing or Cement Room. The band saw was equipped with a flexible exhaust tube above the table and an exhaust around the blade below the saw table. The layout table was equipped with exhaust ventilation as described above. There was no exhaust ventilation supplied on board ship for pipe covering and no workers were found wearing respirators.

Contract Yard C.

There were 51 men working in the shop and 123 on board ship. Layout, cutting and cement

TABLE 1

Summary of Materials Used at Each Yard per Month

	Navy Yard A	Navy Yard B	Contract Yard C	Contract Yard D
Amosite	58,200 sq. ft.	50,000 sq. ft.	40,000 sq. ft.	6,325 sq. ft.
Amosite (water-repellent)	—	15,000 sq. ft.	—	3,300 sq. ft.
Prefabricated sections (molded and block)	600 sq. ft. 39,900 linear ft.	1,200 sq. ft. 115,000 linear ft.	1,750 sq. ft. 18,800 linear ft.	15,700 linear ft.
Asbestos cloth	76,500 sq. ft.	106,600 sq. ft.	34,700 sq. ft.	40,000 sq. ft.
Metallic twine Asbestos yarn	—	150 lb.	—	—
Asbestos paper	—	5,500 sq. ft.	4,000 sq. ft.	5,500 sq. ft.
Asbestos board	2,700 linear ft.	6,000 sq. ft.	150 sq. ft.	—
Asbestos cement	34,400 lb.	15,000 lb.	57,500 lb.	38,500 lb.

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80 700
51 123

mixing were done at one end of the shop. Dust respirators were occasionally worn during these procedures. At the other end of the shop the fabrication of boots, jackets and molds were carried out. A small amount of such fabrication was done on board ship.

Material was cut with a band saw in a separate room and the operator wore an approved dust respirator. The dust from this saw was exhausted through a slot under the table which caught only a part of the dust given off above the table.

There was no exhaust ventilation in the shop, other than for the band saw, and none for the pipe covering operations on board ship. All floors, walls and rafters of the shop were cleaned at frequent intervals with an industrial vacuum cleaner. Most pipe covering on board ship was applied in the evening during the second shift.

Contract Yard D.

There were 8 men in the shop and 160 men working on board ship. Pipe covering operations were done in two shops. In the main one, boots and jackets for pipe valves and connections were fabricated and surplus material stored. In the smaller shop the operations consisted of layout and cutting of amosite, water repellent amosite and fire felt. There was no exhaust ventilation in either shop nor for the pipe covering operation on board ship. All the asbestos cement was mixed in a compartment on board ship. The only worker who wore an approved dust respirator was the man who cut the two types of amosite. There was no band saw cutting of asbestos in this yard.

IV. Analyses of Settled Dust and Dust Counts

There are no established figures for permissible or safe dustiness in pipe covering operations. Dreessen et al. (2) in their study of asbestosis in the asbestos textile industry suggested 5 million particles of total dust by impinger as a threshold for that industry. We should like to point out that the asbestos textile and asbestos pipe covering industries differ widely in their dust exposures. In textile plants workers usually continue at specific jobs with fairly constant dust exposures for some years, whereas the pipe coverer may rotate between shop and ship and from small to large ship compartments with a wide variation in dust exposure.

In contrast to the textile worker, the pipe coverer's materials differ markedly in their asbestos content, ranging from 85 per cent magnesia (10–15% asbestos) to amosite (95% asbestos). When asbestos cements contain large amounts of diatomaceous earth there is a resultant silicosis hazard as indicated above.

In general we feel that dust counts below 5 million particles per cubic foot by Konimeter indicate good dust control.

Our figures in Table 2 were determined by the Konimeter and not with the impinger instrument. We used the Konimeter because it is light, easily portable and takes records which can be kept indefinitely. As is indicated in Table 3, the dustiest operations are band saw cutting, cement mixing, and installation on board ship.

V. Medical Findings

The incidence of asbestosis among pipe coverers as determined by chest X-ray is given in Table 4. The relation between years of exposure and per cent asbestosis is included in Table 5.

Due to frequent turnover of shipyard workers and the length of time required to X-ray a large number of workers, the number X-rayed may not equal the number of pipe coverers. At Contract Yard C X-rays were examined of men who had left the yard while at Navy Yard B a few pipe coverers were not X-rayed. At Navy Yard A the 48 X-rayed out of 551 were all older men working in the shop.

Some of these pipe coverers had had pre-shipyard experience in the asbestos industry, but the tables are based solely on shipyard exposure. At Contract Yard C, for example, the Asbestos Shop estimated that about one-third of their pipe coverers had worked with asbestos before coming to the yard.

The one case of advanced asbestosis at Contract Yard C had worked in the asbestos industry for 23 years before coming to work in the yard. At Contract Yard D the two cases of moderate asbestosis had worked 22 years and 30 years at pipe covering in their yard.

All of the X-ray films used in the above data were first read by roentgenologists of the Medical Department of the yard and then by one of the authors (W. E. F.). Dr. W. C. Dreessen, U. S. P. H. S., was kind enough to examine the three positive plates and he agreed on the diagnosis.

Since only three workers out of the 1074 X-rayed had asbestosis, and each of the three had been a pipe coverer for more than 20 years, it would

TABLE 2

ANALYSES OF SETTLED DUST AND AIR SAMPLES

OPERATION	PER CENT LESS THAN 10 MICRONS BY COUNT	ASBESTOS (BELOW 200 MICRONS)	PER CENT LESS THAN 10 MICRONS BY COUNT						DUST COUNTS (MPPCF)*					
			Diatomaceous earth	Serpentine	Other fibers (organic & glass)	Iron oxide (opaque)	Carbonates and oxides	Others	Number of samples	Total dust: Range of counts	Total dust: Average	Asbestos dust: Range of counts	Asbestos dust: Average	Per cent asbestos (range)
Layout and cutting														
Navy Yard A	95	16	6	12	6	24	26	10	2	3.5– 8.7	6.1	0.21–0.50	0.35	3.7– 6.0
Navy Yard B	98	10	8	12	tr	40	18	12	7	1.6– 6.5	4.2	0.01–0.54	0.23	0.6– 7.9
Contract Yard C	95	30	5	10	tr	26	14	15	4	17.1– 25.2	20.5	1.13–4.30	2.18	6.6–19 5
Contract Yard D	95	26	6	8	tr	29	21	10	5	6.5– 16.5	10.9	0.09–1.16	0.63	1.4– 8.7
Cutting with band saw														
Navy Yard A									2	11.0– 19.2	15.1	0.10–0.14	0.12	0.7– 0.9
Navy Yard B	98	9	7	8	tr	48	16	12	2	32.4– 46.6	39.5	2.8– 3.2	3.0	6.5– 8.7
Contract Yard C	98	9	63	2	tr	10	4	12	3	15.2–100+	73+	.9–12.8	6.19	4.3–12.5
Molding operations														
Contract Yard C	98	8	66	3	tr	7	6	10						
Contract Yard D	95	4	9	7	tr	38	10	12						
Sewing & prep. of boots & jackets														
Navy Yard A									2	3.3– 6.1	4.6	.01– .06	0.03	0.3 –1.0
Navy Yard B (Sewing asbestos cloth)	98	12	tr	9	tr	42	21	16	3	3.3– 6.0	6.8	0.0– 9.4	0.1	0. –6.4
(Stuffing with amosite)	98	8	8	11	tr	38	20	15	1	2.1–	2.1	0.	0.3	0.
Contract Yard C	95	26	6	11	3	28	12	14	2	10.6– 12.3	11.4	.45– .79	.62	3.7 –7.4
Contract Yard D	98	6	6	8	tr	38	25	14	5	3.9– 10.9	6.0	0. – .05	.05	0. –0.5
Storeroom														
Contract Yard D	95	15	8	7	tr	26	32	12						
Cement mixing														
Navy Yard A									16	5.4– 30+	31+	0. –0.52	0.2	0. – 0.7
Navy Yard B									2	67. –100+	84+	1.6 –1.7	1.7	1.4– 2.5
Contract Yard C									2	33.8– 48.7	41.3	1.6 –4.7	3.1	4.7–10.0
Contract Yard D (on board ship)									5	19.6– 40.0	32	0. – .02	.01	0. – .031
Grinding scrap materials														
Navy Yard A	88	8	20	16	1	10	33	12	15	9.4–100+	50+	0. –1.6	.47	0. –2.5
General room														
Navy Yard A									49	0.2– 24.6	10.0	0. –1.4	0.08	.02–0.5
Navy Yard B									2	1.6– 3.3	2.4	0. – .01	.01	0. –0.6
Contract Yard C									4	0.0– 21.6	14.2	0.34–1.7	.8	3.8 –7.9
Contract Yard D									5	3.9– 10.9	6.0	0. – .05	.02	0. –0.5
Aboard ship														
Navy Yard A									30	65. –250.	142	0. –0.17	0.02	0. –0.05
Navy Yard B									15	84.4–192.0	128	1.36–5.21	2.8	1.1 –3.7
Contract Yard C									13	25.3– 89.0	49.2	0.23–2.35	1.1	0.5 –6.3
Contract Yard D									15	8.0– 22.1	11.0	0. –0.21	0.03	0. –1.0

* *Note:* MPPCF = Million particles of dust per cubic foot of air.

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TABLE 3

COMPARISON OF DUSTINESS OF VARIOUS OPERATIONS IN EACH SHIPYARD

OPERATION	NAVY YARD A		NAVY YARD B		CONTRACT YARD C		CONTRACT YARD D	
	Total dust	Asbestos dust	Total dust	Asbestos dust	Total dust	Asbestos dust	Total dust	Asbestos dust
	MPPCF*		MPPCF		MPPCF		MPPCF	
Layout and cutting	6.1	0.35	4.2	0.23	20.5	2.18	10.9	0.63
Band saw cutting	15.1	0.12	39.5	3.0	73.0	6.19		—
Sewing and fabrication	4.8	0.03	64.8	0.1	11.4	0.62	6.0	0.03
Cement mixing	31.0	0.2	84.0	1.7	41.3	3.1	32.0	0.01
Grinding	50.0	0.47		—		—		—
General room	10.0	0.08	2.4	0.01	14.2	0.8	6.0	0.02
Shop average	30.0	0.25	26.9	1.0	32.0	2.6	7.6	0.23
Ship average	142.0	0.02	125.0	2.8	49.2	1.1	11.0	0.03

* *Note:* MPPCF = Million particles of dust per cubic foot of air.

TABLE 4

INCIDENCE OF ASBESTOSIS AMONG PIPE COVERERS

SHIPYARD	NUMBER OF PIPE COVERERS	NUMBER X-RAYED	NUMBER OF CASES OF ASBESTOSIS		
			Minimal	Moderate	Advanced
Navy Yard A	551	48	0	0	0
Navy Yard B	750	662	0	0	0
Contract Yard C	174	196	0	0	1
Contract Yard D	168	168	0	2	0
Totals	1653	1074	0	2	1

TABLE 5

RELATIONSHIP BETWEEN LENGTH OF EXPOSURE AND INCIDENCE OF ASBESTOSIS

SHIPYARD		YEARS IN PIPE COVERING INDUSTRY			
		0-2	2-5	5-10	10 plus
Navy Yard A	Exposed	26	13	8	3
	Affected	0	0	0	0
	Percentage	0%	0%	0%	0%
Navy Yard B	Exposed	225	433	67	22
	Affected	0	0	0	0
	Percentage	0%	0%	0%	0%
Contract Yard C	Exposed	0	105	45	17
	Affected	0	0	0	1
	Percentage	0%	0%	0%	6%
Contract Yard D	Exposed	26	118	5	9
	Affected	0	0	0	2
	Percentage	0%	0%	0%	22%

appear that asbestos pipe covering of naval vessels is a relatively safe occupation. However, it must be remembered that these men rotated among the various operations of pipe covering and were not continually exposed to high concentrations of asbestos dust as found in band saw cutting and cement mixing. The suggestions made relative to exhaust ventilation and respiratory protection are therefore of value in maintaining this low incidence of asbestosis.

DISCUSSION

The extremely low incidence of asbestosis found, 0.29 per cent, or 3 cases out of 1074 pipe coverers, stands in marked contrast to the high dust concentration found in several of the pipe covering operations. As shown in Table 3, the total dust concentration for band saw cutting ranged from 13.1 to 73.0 million particles per cubic feet, for cement mixing from 31.0 to 84.0, and for installation on board ship, from 11.0 to 142.0. The solution of this apparent discrepancy lies in a characteristic peculiar to the pipe covering trade, that is lack of a necessity for specialization. In general, pipe coverers are capable of doing all of the operations described above, and the worker may be changed from one operation to another or to different jobs in the same type of operation without loss of efficiency and according to the demands of ship construction. It is therefore apparent that a pipe coverer's environment may change every few days or few weeks at the most with a constant fluctuation in the dust concentration which he breathes. Therefore, the figures given in Table 3 for shop average and ship average cannot give a composite picture of the asbestos